SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

FRIDAY, APRIL 17, 1908

CONTENTS

Medical Laboratories—Their Relations to Medical Practise and to Medical Discovery: PROFESSOR LEWELLYS F. BARKER ... 601

The American Association for the Advancement of Science:—

Section B—Physics: PROFESSOR ALFRED D. COLE 611

Scientific Books:—

Bower's The Origin of a Land Flora: PROFESSOR CHARLES E. BESSEY. *Bouvier's Monographie des Onychophores:* T. D. A. C. 618

Scientific Journals and Articles 621

Societies and Academies:—

The Section of Geology and Mineralogy of the New York Academy of Sciences: DR. CHARLES P. BERKEY. *The Biological Society of Washington:* M. C. MARSH. *The Philosophical Society of Washington:* R. L. FARIS. *The Anthropological Society of Washington:* DR. WALTER HOUGH 622

Discussion and Correspondence:—

Toxicity as a Factor in the Productive Capacity of Soils: PROFESSOR F. H. KING 626

Special Articles:—

A New Apparatus for Measuring Electrolytic Resistance: PROFESSOR ARTHUR WHITMORE SMITH 635

The American Association of Museums: PAUL M. REA 636

Scientific Notes and News 637

University and Educational News 639

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

MEDICAL LABORATORIES: THEIR RELATIONS TO MEDICAL PRACTISE AND TO MEDICAL DISCOVERY[1]

To be asked to give an address on an occasion so worthy of joyful and honorable celebration as that which has brought us together to-day is an honor of which I am far from being insensible. When the invitation to the formal opening of your new building came in letters from my former schoolmate, Dr. Third, and the dean of your medical faculty, Dr. Connell, I was much pleased; though I knew that it came to me mainly on account of the fact that I happen to occupy a chair in an institution especially identified with medical laboratories, medical instruction and medical research, I could not help but feel grateful to fortuity for the favor she brought. Born in Canada, educated in Canadian schools, a graduate of a medical college in this province and at one time licensed to practise among the people of Ontario, I have every reason for filial affection to this great country and rejoice in my right to share your pride in its phenomenal advance. And no advance seems to me greater than that which you have been making in the betterment of medical education and in the promotion of medieal knowledge; one striking evidence of it is before us in the new building which you have just now met to dedicate.

The subject which I have chosen for my remarks, namely, "Medical Laboratories:

[1] An address delivered at the formal opening of the Medical Laboratories Building, Queen's University, Kingston, Canada, January 14, 1908.

their Relations to Medical Practise and to Medical Discovery," is of such great importance that I wish I felt myself more competent adequately to discuss it. The topic has the advantage, however, that no skill on my part is necessary to excite your interest in it, for the current of your thought is, by the occasion, set in its direction. The completion of this building indicates the lively sympathy of members of your university with laboratory medicine; the substantial aid which an enlightened legislature has given you is proof that there is already some appreciation of the fact that the benefit of such laboratories is not to individuals alone, but also to the people at large and that the appropriation of public funds for their construction and maintenance is justifiable. Without occupying a great deal of your time or dissipating too much of your energy I shall try to make plain to the less medical portion of this audience how it is that medical laboratories such as have been built here have become a necessity, how indispensable they are for the training of doctors who are to care for the sick, of what use they may be in helping physicians actually to utilize, in cases of serious illness, the fruits of the more recent medical discoveries, and finally how, if provision be made in them, as should be and doubtless will be, for the undertaking of original investigations directed toward the solution of some of the medical problems now pressing, we may hope that here in Kingston new knowledge may be acquired which will make medical men able, better than now, accurately to predict, and give them greater power than they yet possess to cure and to control. And while I congratulate you heartily on the position to which you have now attained in the matter of laboratories, I intend to point out (what those among you best informed as to medical progress fully realize) that the policy of laboratory expansion upon which you have entered is in reality but a beginning and will lead irresistibly later on to still further, and perhaps fully as important, developments in your medical school.

THE DEVELOPMENT OF SCIENTIFIC MEDICINE AND OF MEDICAL LABORATORIES

Every one knows nowadays what is meant by the scientific method. It consists in gathering facts carefully, arranging them according to their similarities and sequences and finally epitomizing them in the form of brief formulas or so-called general laws. As a result thought is economized and suitable action follows most surely and quickly upon impressions of sense.

Medical science, like all natural science, began with simple observation. The physician first by means of his unaided sense organs collected sense impressions. This simple observation could not, however, take him very far, for it was too inexact. It became necessary to invent artificial aids for extending the powers of the sense organs and for rendering their measurements more precise. Medical men learned how to experiment so that their observations could be made under peculiarly favorable circumstances. They have found out how to interrogate nature and to compel her to answer; on inquiry they see to it that their attention is specially prepared; their interest in observation is sharpened by the particular question asked.

Hippocrates, the most accurate of ancient medical observers, realized the importance of contact with natural objects; it was his opinion that this must be the basis of all medical knowledge. "The student must rub and grind at nature, using his reason at the same time; but his reason must be a perceptive and interpretative, not a productive, faculty, for he who lends himself to plausible ratiocination will find himself

ere long in a blind alley; and those who have pursued this course have done no enduring service to medicine." It was the accessibility of external medicine or surgery to direct observation that accounts for the more solid foundation early laid in that branch of medicine; inner medicine, in which there was but relatively little opportunity for direct observation, was the field for rank speculation for centuries, and it was not until experimental researches began to be undertaken systematically that inner, as contrasted with outer, medicine began to make significant progress.[2]

The history of the development of experimental work is very closely connected with the history of scientific laboratories. The bibliography of this subject is surprisingly small; an unusual opportunity for an interesting and instructive historical contribution lies open to him who will trace carefully the origins of laboratory work and their relation to the development of natural science in general.[3] In the third century before Christ several natural sciences, including anatomy, physiology and pathology, were cultivated in state-supported institutes in Alexandria. Though the apparatus was probably crude, there is evidence that students in these institutes studied nature by coming into direct personal contact with the objects of study. With the decline of the Alexandrian school, however, this method of practical study fell into desuetude, and, except for the experimental physiological methods of Galen (second century A.D.), and perhaps a little anatomical work at Salernum (thirteenth century), it was chiefly the surgeons —men like Hugh of Lucca, Theodoric of Cervia, Guy of Chauliac—who, keeping their hands at work, managed to cultivate medical studies more or less objectively. Benivieni (1448–1502), the founder of the craft of pathological anatomy and forerunner of Morgagni, seems to have been "the first to make the custom, and to declare the need of necropsy to reveal what he called . . . the hidden causes of diseases." In the fifteenth and sixteenth centuries came the great development of human anatomy. Vesalius published his wonderful volume in 1543, and anatomy has ever since his time been studied by dissection of the human body. Anatomical laboratories for teaching and investigation have been in existence for more than three hundred years; indeed, the anatomical laboratory has priority in foundation over all other scientific laboratories.

It was not, however, until the nineteenth century that the scientific spirit and scientific work became the main characteristic of the age. The nineteenth century has been designated therefore the scientific century, just as the eighteenth was called the philosophical century, the sixteenth the century of the Reformation and the fifteenth the century of the Renaissance.[4] The great inventions before the nineteenth century were made without special scientific knowledge and were brought about "more by accident or by the practical requirements of the age than by the power of an unusual insight acquired by study." During the last fifty years the great discoveries have been made in scientific laboratories. Whereas, formerly, necessity was the mother of invention, latterly the tables

[2] Cf. Allbutt, T. C., "The Historical Relations of Medicine and Surgery." Reports of the Congress of Arts and Science, Universal Exposition, St. Louis, 1904, Vol. VI.; Boston and New York, 1906, 189–209.

[3] An excellent résumé of the subject as far as medical laboratories are concerned is to be found in an address by Professor W. H. Welch entitled "The Evolution of Modern Scientific Laboratories," delivered at the opening of the William Pepper Laboratory of Clinical Medicine. *Johns Hopkins Hosp. Bull.*, Baltimore, 1896, VII., 19–24.

[4] Cf. Merz, J. T., "A History of European Thought in the Nineteenth Century," Edinburgh and London, 1904, p. 89.

have been turned and scientific discoveries have produced new practical needs and created new spheres of labor, industry and commerce.

Though physical researches were carried on from the time of Galileo downward and chemical work goes back to the age of the alchemists who sought for the philosopher's stone, the first distinctly modern scientific laboratories appeared in Europe in 1824 and 1825. In the former year Purkinje established a physiological laboratory in Breslau, and the year after Liebig, in Giessen, opened a chemical laboratory for the use of students and investigators; the latter laboratory, stimulated from two independent centers—Berzelius's laboratory in Sweden and Gay-Lussac's in Paris—developing in the atmosphere of the German ideal of *Wissenschaft,* was destined to exert the greatest influence upon the development and organization of other laboratories for scientific work. In 1856 Virchow established the first pathological laboratory in Berlin. Dorpat was the home of the earliest independent pharmacological laboratory, established there by Buchheim in 1849. Physiological chemistry was housed in a laboratory of its own in Strassburg in 1872 (Hoppe-Seyler), and hygiene at the instance of Pettenkoffer was given a special institute by the Bavarian government in 1872. The first clinical laboratory proper was started in the Munich Hospital by von Ziemmsen about 1886. Still later came special laboratories for psychopathic studies. Now every university in Germany has a complete set of these laboratories and there are in that country, all told, more than two hundred such medical institutes.

From Germany the exact spirit of research by means of organized laboratories spread rapidly to other countries—to England, Scotland and America, but Germany has the credit of the first and most extensive laboratory development; it is to this development that she owes her leadership in medicine and the biological sciences during the last eighty years.

Liebig's chemical laboratory was opened in a small town, not in a great city, and in this there were certain advantages. In an autobiographical memoir Liebig has said: "I always remember with pleasure the twenty-eight years which I passed at Giessen; it was, as it were, a higher providence which led me to the small university. At a large university, or in a larger town, my powers would have been broken up and frittered away, and the attainment of the aim which I had in view would have been much more difficult, if not impossible; but at Giessen all were concentrated in the work, and this was a passionate enjoyment." "A kindly fate had brought together in Giessen the most talented youths from all countries of Europe. . . . Every one was obliged to find his own way for himself. . . . We worked from dawn to the fall of night: there were no recreations and pleasures at Giessen. The only complaints were those of the attendant, who in the evenings, when he had to clean, could not get the workers to leave the laboratory.[5]

The peculiar advance made by Liebig's laboratory was the introduction of systematic and methodical training on an especially devised plan by which young men were introduced to a thorough practical knowledge of chemical properties and manipulations. The laboratory became the training school for the majority of chemists outside of Paris, and was used as a model for similar establishments in other cities in Germany as well as in other countries. This laboratory convinced the world of what could be done in an institution containing suitable workrooms and adequate equipment in apparatus, with proper materials for study, including ready access

[5] Cf. *Deutsche Rundschau,* Vol. LXVI., 30–39. Cited by Merz.

to books and scientific journals, especially when a director, who can give his whole time to teaching and research and is filled with the enthusiasm of his subject, leads the way. Later on, in Berlin, Johannes Müller did for physiology what Liebig had done for chemistry, and many of the physiological chairs in European universities were filled subsequently by men who had worked under Müller.

It goes without saying that laboratory buildings alone, even when adequately equipped and with a liberal maintenance budget, are far less important than the men who work in them. Nevertheless, experience teaches that in cities and countries where the laboratory facilities are most ample there, on the whole, more and better men apply for training, and a greater number of important discoveries are made.

An obstacle in the way of laboratory expansion has been the great cost of such institutions. While the buildings themselves are not necessarily very expensive, still the outfit needed often entails a large outlay, and unless the director and his assistants are paid sufficient salaries to permit them to devote all or almost all their time and energies to the work but little progress is likely to be made. Moreover, the expense of supplies for the experimental work in such laboratories is great and a liberal annual budget is therefore an essential. The scientific workers, too, should be provided with a certain number of paid mechanical helpers, for where the best brains in the laboratory are hampered by the necessity of doing the work which could just as well be done by laboratory servants a serious economic mistake is made.

The endowment necessary for modern laboratories has been one of the main factors in leading to the disappearance of proprietary medical schools, since a medical school conducted by modern methods can no longer be run for profit. Indeed, large sums of money are absolutely necessary for the conduct of modern medical education, and unless these endowments are available through private benefaction, they should be provided by the state. It may be asserted safely that at the present time money can not be invested to better purpose than in judicious support of medical laboratory work. A survey of the results of such work shows a greater return in practical benefits to mankind than can be claimed perhaps by any other mode of utilizing the money. The medical discoveries of the last twenty-five years demonstrate conclusively that the endowment of medical science yields an enormous reward, and nothing seems more likely than the probability that those medical schools and those countries which fall behind in the maintenance of medical laboratories and of scientific workers in medicine are destined to occupy an inferior place in medical education and to remain behind in social and economic importance.

MEDICAL LABORATORIES AS A TRAINING PLACE FOR PHYSICIANS

A large part of the education which medical students receive nowadays is given to them in laboratories. Instead of the didactic lecture of former periods the student in a medical school of our time does practical work in nearly all the subjects of the medical course. In the anatomical laboratory he dissects the human body and examines its constituent organs, tissues and cells under the microscope, making many of the preparations for himself. In the physiological laboratory he studies the functions of the animal body less from books and from lectures than from actual observation, as he repeats the experiments of the great masters who have made fundamental physiological discoveries. In the pathological laboratory he assists in the

making of post-mortem examinations, studies the changes in form, consistence and color of organs in disease, and under the microscope investigates the finer changes in the cells and intercellular substances in pathological states. In the better laboratories of this sort, too, he has the opportunity of witnessing the phenomena of life as manifested under abnormal conditions, and though pathological physiology as such has not yet reached the place in our medical schools which it seems destined to occupy, it is rapidly being developed and promises to become in the near future one of the most important features of undergraduate medical instruction. In the bacteriological laboratory the student not only hears of bacteria and of their relations to fermentation and to disease, but he handles these bacteria himself, studies them, alive and dead, under an oil immersion lens, grows them artificially upon media prepared by himself, produces certain of the infectious diseases experimentally by inoculation of animals, and recovers from the bodies of the diseased the same microorganisms which he has inoculated. He is given, too, a practical acquaintance with the simpler methods of studying the phenomena of immunity, and gains in this way a unique conception of the nature of infection and the tendency of self-limitation of the infectious diseases; he becomes familiar with the fundamental principles of contagion on the one hand and of prevention on the other. These studies, together with those which he makes in the laboratory of hygiene, prepare him, in a way unequaled by any other form of preparation, for meeting those problems of personal hygiene and public safety which confront the medical man in private practise and in the protection of the public health. In the laboratory of physiological chemistry the medical student perfects his methods of chemical manipulation and examines for himself the various chemical constituents of the human body and its secretions and excretions. One needs no special prophetic instinct to recognize how important a training of this kind is for the prospective physician who will wish to keep abreast of medical advance during the next two decades, for there seems to be but little doubt in the minds of those best informed that the laboratories of physiology and physiological chemistry are to stand in much the same important relation to medicine during the next twenty years as that occupied by the laboratories of pathology and bacteriology since 1880. Furthermore, practical pharmacological studies are now essential for the medical student. The undergraduate who in the pharmacological laboratory studies the physiological effects of drugs by actual observation of the effects produced after administration to animals, making accurate measurements by the precise methods of physics and chemistry, will acquire an insight into the possibilities and limitations of treatment by drugs which will protect him from a pessimistic nihilism on the one hand, and, even more important, from uncritical enthusiasm on the other. The student thus trained will be less likely to fall a prey to the proprietary medicine manufacturer and the nostrum monger than the physician who has obtained all his knowledge concerning the action of drugs from books, lectures or the circulars of manufacturers.

In the clinical laboratories associated with the wards of the hospital the student will be taught how to apply the knowledge gained in all the laboratories just mentioned to the problems of diagnosis and treatment as he actually meets them in his study of patients in the hospital wards and dispensaries. These hospital clinical laboratories have only just begun their development, and there are but few medical schools which have made adequate provision for

them. I have in another place[6] called attention to the great importance of these laboratories for the training of medical students as well as for the advance of practical medicine, and have tried to show that it is just as necessary for physicians and surgeons to have their own special laboratories attached to their wards, in which chemical, physical, bacteriological and psychic investigations can be made as it is for aniline dye manufacturers to have chemical laboratories attached to their plants for solving their special problems, or for brewers to have bacteriological laboratories and skilled bacteriologists constantly at work to maintain and improve the standard of their products. It will not do for the sciences of diagnosis and therapy to rely upon the laboratories of chemistry, physiology and pathology in the medical school to solve their particular problems for them. The more fundamental sciences have their own problems of a more abstract nature which it is their duty to investigate, and the time has certainly come for diagnosis and therapy to develop the laboratory sides of these sciences for themselves.

By far the greatest advantage of instruction of the medical student by the laboratory method is, however, his training in the scientific habit of thought. What helps him is less the facts which he learns, or the memory of the experiments he makes, than the establishment in him of the conception that in order really to understand it is necessary to come into direct personal contact with the object to be understood. If some of his teachers are, and certainly some of them should be, productive investigators, he is likely to be impressed with the necessity of accuracy in work, of patience in it, if things are to be accomplished, of steady industry and persevering effort. He learns also to have a love for detail and a desire for complete and exhaustive knowledge; he comes to appreciate skill in invention and in the application of new and precise methods, and there grows in him a desire for full appreciation of the value of all existing methods or principles which will prevent him from falling a prey to sectionalism in medicine or to any single idea or principle which is limited in its nature. In other words, he develops in those three directions of thought which characterize three more or less distinct and important attitudes of the human mind; namely, the exact habit or attitude of thought, the historical and the critical.

[6] Barker, L. F., "The Organization of the Laboratories in the Medical Clinic of the Johns Hopkins Hospital," *Johns Hopkins Hosp. Bull.*, June–July, 1907.

THE UTILIZATION OF LABORATORIES BY PRACTITIONERS AND HEALTH OFFICERS FOR THE DIAGNOSIS, CURE AND PREVENTION OF DISEASE

I have referred incidentally to the use of hospital laboratories by hospital physicians and surgeons as direct aids in the diagnosis and treatment of their cases. The chemical, physical, microscopical and bacteriological studies now made in hospital wards form a large part of the occupation of resident and attending physicians in those institutions; indeed, the examinations of the blood, of the urine, of the stomach juice, of the sputum, of the fæces, of the cerebro-spinal fluid, of the contents of abscesses and cysts, of portions of tissue removed at operation and X-ray and electrical examinations have become so potent a factor in medical diagnosis that many have begun to fear that physicians and medical students in their enthusiasm for the clean-cut results which they yield may come too much to neglect the older fundamental methods of inspection, palpation, percussion, auscultation and mensuration. And it is certainly wise that a note of warning should in this connection be

sounded, for it would be a grave error to deprive ourselves of what is good in the old because of the helpfulness of the new. That such a fear should be expressed, however, shows how tremendous a hold laboratory methods are taking of the minds of developing clinicians.

Aside, however, from the laboratories connected with hospital wards there has been in recent years a phenomenal growth of private and public laboratories in our towns and cities for the use of private practitioners of medicine and officers of public health. I am sure that the laity scarcely realizes how much such laboratories promote the early diagnosis and facilitate the treatment of disease, and especially to how great an extent through them infectious and contagious diseases in the community are prevented and controlled. Time will not permit me to enter upon an enumeration of these particular benefits. I desire, however, to express my gratification at learning that at least some portion of these new laboratories which you have built in Kingston is to be devoted to the service of the public health, and I predict that no small part of their usefulness to this community and to the people of this province will result from the activities of the public health division of your laboratories.

MEDICAL LABORATORIES AS CENTERS OF RESEARCH

In addition to being necessary and desirable places of instruction for medical students and also institutions for practical use in the prevention and cure of disease by physicians and officers of the public health, medical laboratories subserve a still higher purpose, to which we should for a few moments advert,—I mean the function of medical research. In university circles no special plea for original research is necessary I know, for in those circles the advantages of creative inquiry, both from the economic side and from the standpoint of the highest human ideals, are well understood. It is to be feared, however, that the general public, sympathetic as it is with scientific advance in general and with the efforts made by scientific investigators in the struggle for enlightenment, has no adequate realization of the results which have already attended the studies of medical scientists or of the urgency for the promotion of original studies in strictly medical domains. The public has always been willing to pay for hospitals to care for the sick, but it is only in recent years that it has begun to awaken to the possibilities of preventing disease by the endowment of research specifically directed thereto.

The advances which have been made in our own time by investigative medicine are truly phenomenal, and no layman, unless he has made a special point of looking into the matter, has any conception of the increased power medical men now possess to lessen physical suffering from disease and accident, or the means at their command for controlling the spread of infectious and contagious disease. Not only has the prospect of life for each human individual been markedly lengthened, but immeasurable advantages have accrued to the race as a whole, no small part of our industrial development at home and the opening up of countries abroad hitherto inaccessible to civilized whites having been due to the protective discoveries of modern medical science. It is not my purpose at this time to review even briefly the triumphs of modern preventive medicine, interesting as it would be to outline to you what has been done regarding the cause and the prevention of diseases like typhoid fever, Asiatic cholera, bubonic plague, yellow fever and malaria. The advances made in the prevention and cure of diphtheria and in the lessening of infant mortality are

familiar even to the layman, and in the great crusade against tuberculosis now in progress all over the world we have a demonstration of the growing consciousness of the public that it is necessary for it to combine with physicians in applying scientific methods to the extermination of that dreadful malady which is the cause of death of one out of every eight of our people. Since scientific methods when applied to the solution of medical problems have so soon been able to yield the striking results at which I have hinted, what may not be done if more men and more money can be made available for the study of the diseases which as yet can not be controlled. Think of the benefits to the human race which would follow the discovery of a means for preventing or curing pneumonia, an infection which in spite of all the work yet done upon it kills as many people to-day as it did one hundred years ago; or what a boon it would be to human society if the secret of cancer and sarcoma and other malignant tumors could be unraveled and these dire diseases become as controllable as have diphtheria and wound infection. Another most important field for investigation is that which deals with the disorders which affect human beings after middle life is past and account for much of the misery which leadens the sky of so many men and women in their advancing years; I mean those degenerations of the blood vessels, kidneys, liver and brain, the origins of which are as yet obscure and the prevention of which we have yet to learn.

Germany took the lead in the recognition of this special research-function of the medical laboratory and of its significance for social progress. In 1880 the German government endowed a special laboratory—that of the Imperial Health Office—for the investigation of the infectious diseases, and put Koch at its head. France followed quickly with that great institution of international reputation founded for Pasteur after his epoch-making discovery of a method for preventing the development of hydrophobia after mad-dog bites. Since then special institutes for purely investigative purposes have been springing up like mushrooms, part of them supported by national governments, others endowed by private individuals of wealth and insight. I need only mention the Imperial Institute for Experimental Medicine in St. Petersburg (1890), the Institute for Infectious Diseases in Berlin (1891), the laboratory now known as the Lister Institute in London (1891), the Institute for Experimental Therapeutics in Frankfurt (1896), the State Laboratory for the Investigation of Cancer in Buffalo (1899), the Rockefeller Institute for Medical Research in New York (1901), the Institute for Infectious Diseases in Chicago (1902) and the Phipps Institute for the Study of Tuberculosis in Philadelphia (1903)—all establishments dedicated to original medical inquiry—to show you how rapid has been the expansion in this direction. Nor does such an enumeration exhaust by any means the list of medical laboratories engaged in special research. The better university laboratories combine research work with the work of instruction, and much excellent scientific labor is also performed in the laboratories of boards of health in our larger towns and cities.[7]

The people of Canada and the United States are to be congratulated upon the increase in public interest in medical research on this side the Atlantic during the last few years; nevertheless, there is still

[7] Cf. Welch, W. H., "The Benefits of the Endowment of Medical Research," an address delivered at the opening of the laboratories of the Rockefeller Institute for Medical Research, New York, 1906.

a great shortage of men here as compared with the number available for such work in European countries. It must be confessed, too, that the scientific output of individual workers in this country is smaller than it should be and could be were the conditions for work made more favorable. As yet we have only a handful of men who devote their whole time and energies to this kind of study and these are hampered in their work by serious defects in the conditions which surround medical research in America. In our medical schools the professors who are able to do investigative work and have the desire therefor, are often so overloaded with the routine work of lecturing, laboratory instruction and administration, that they really have not the time for the intense and absolutely undisturbed work necessary for the creative mind. Further, it is rare in this country to find an investigating professor supplied with research assistants to help him practically to carry out his ideas, whereas in Germany, by means of a graded staff and a department budget which permits the employment of several research assistants, the hands of the man with original notions are multiplied several fold and there is a much more rapid conversion of new ideas into new results.[8] Another hindrance to research lies in the insufficient financial rewards of academic work. We are undoubtedly holding back our people and the prestige of the country in which we live by the inadequate provision we are now making for the material side of the lives of professors in our universities and medical schools. This is false economy; commercially speaking, it is bad business. Until university trustees and the public generally recognize the necessity of retaining the best brains which develop among us in the service of instruction and research the activities of those brains will inevitably, in many instances, be diverted to other fields. The man with investigative ability, with the power of observing closely, of reasoning accurately, of thinking originally and of experimenting rigorously, is rare. The critical attitude of mind, the inspiration to originate, the training which makes men able to extend the boundaries of knowledge and to win new power from nature, is not common. Only a few men have the faculty of determining and grasping facts, and of verifying and digesting them; and still fewer have the ability to conceive fruitful hypotheses connecting these facts or explanations, united with the initiative necessary to test the validity of the hypotheses by experiment. Research work requires a patience and an enthusiasm, a self-denial and a perspicacity unknown to the average man. When we discover a worker who can find his way in medical regions as yet untrodden, who can discern new relationships among facts, who can elucidate some of the mysteries which for centuries have puzzled us, we should cherish him. He needs all our sympathy and support, for the conditions under which he works are lonely and difficult. He has, as a rule, but few companions, and his work is not in the public eye. He has to set his own tasks and to establish his own standards of excellence. Fortunately, he is a man of high ideals and his reward comes chiefly from his work, from the actual joy of the labor. But, since the results not only increase knowledge but promote the safety and happiness of the people, it is the duty of society to provide the facilities and conditions for his work, to elevate his position in life and to give him the honor and appreciation consonant with his high calling.[9]

[8] Cf. Stieglitz, J., "Chemical Research in American Universities," Science, N. S., 7, 1907.

[9] Cf. Eliot, C. W., "The Qualities of the Scientific Investigator," address at the opening of the laboratories of the Rockefeller Institute, New York, May 11, 1906.

In bringing my remarks to a close I hope that their main intent, despite their rambling and somewhat desultory character, may have become plain to you. I have tried to show you that medical laboratories such as these are indispensable in medical schools which are at all worthy of being known as the medical departments of true universities, and I have maintained that only in such laboratories can students be properly taught, for they come there into direct personal contact with the objects of study, a requisite if the scientific habit of thought is to be engendered. To them, too, your physicians and your guardians of the community's health may resort for making the special laboratory examinations now necessary for the diagnosis, the cure and the prevention of the ills by which your people are afflicted. And, above all, opening off these halls there are some rooms which will, I trust, become the workshops of mature original investigators and others which will serve as nurseries in which will be cultivated those qualities of mind, heart and hand which make men dissatisfied with knowledge as it is and compel them to try to extend it.

Untrammeled by the traditions and ultra-conservatism which are holding medicine back in the mother country, yet protected by intimate connection with her from the whimsical vagaries, the wildness and the freakishness which might otherwise tend to bring medical science here into disrepute, Canadians have an opportunity and a privilege in medicine they will not be slow to take advantage of, a duty they are sure manfully to assume. There are many young men and women in this country and this province capable of devotion to an ideal cause, independent of personal gain and glory. It is to the credit of Canadian parents that they instil into their children high and noble aspirations, that they teach them to endure privations cheerfully for the sake of things greater than mere physical comforts, and that they cultivate that generosity and elevation of spirit which make unselfish human effort not only possible, but really desirable. The fruits of this training will, I dare prophesy, become evident sooner or later in the activities of these laboratories. In them there will be professors and students who will choose as their life work the pursuit of medical truth and the acquisition of medical knowledge for its own sake; as a result of this ennobling and worthy occupation human suffering will be ameliorated, and, perhaps, some patients suffering from maladies now incurable may be healed. May the high aims and purposes of those who have planned these buildings and made their erection possible be realized! May the good that you hope for be the outcome of work in the laboratories which with suitable solemnity and earnest purpose you have set apart and consecrated to a special service to-day!

LEWELLYS F. BARKER
THE JOHNS HOPKINS UNIVERSITY

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
SECTION B—PHYSICS

II

A Relation of Mass to Energy: DANIEL F. COMSTOCK, Ph.D. (Read by title.)

In the paper of which this is an abstract it is shown that the momentum of any purely electric system having any internal motions and constraints, but possessing on the whole a kind of average symmetry, is given by the expression

$$M = \frac{2W^T v}{V^2[1 + (v/V)^2]}.$$

Here M is the momentum of the system, (v) its velocity as a whole, V the velocity of light and W^T the part of the total electromagnetic energy which is represented

by the components of the electric and magnetic forces which lie perpendicular to the direction of motion of the system. This is a highly general result and is obtained by a method involving the generalized constraints of the system.

When the second order of the ratio v/V may be neglected, W_T is equal to two thirds the total electromagnetic energy (W) of the system (because of the average symmetry before mentioned), and hence we have

$$\text{Mass} = 4/3\ 1/V^2\ W.$$

This gives the electromagnetic mass of the system in terms of its total energy content.

If the electrical theory of matter be accepted this result applies to the mass of any piece of matter and we have the mass proportional to the total contained energy.

It is shown that if this hypothesis is accepted the irregularities which exist in the table of atomic weights are in harmony with the evolutionary theory of the elements.

Also on this basis gravitation must be considered as acting between quantities of confined energy and not between masses in any other sense.

Method of Determining the Modulus of Bending of a Flat Spring: R. S. Woodward, Carnegie Institution of Washington. (Read by title.)

The method applies especially to a uniform flat spring held rigidly and horizontally at one end but otherwise free to assume the shape due to its weight. The exact theory of this shape shows that measurements (1) of the vertical sag of the spring at any point of its length, (2) of its weight per unit length, and (3) the total length of its free part will give the modulus of bending.

An Investigation of the Optical Properties of Films of Magnetic Metals: C. A. Skinner and A. Q. Tool, University of Nebraska.

This paper deals with the magnetic rotation and ellipticity produced by films of iron, cobalt and nickel of definite thicknesses together with the refractive indices, reflection and transmission of the same.

It appears that two distinct types of films may be produced by cathode deposit *in vacuo*, one a *metallic* the other a *dark* film. The difference does not arise from the gas in which the films are produced, for they are alike, whether hydrogen, nitrogen or helium be used as gas filling.

The optical properties of these different types are quite different, and they also differ from those obtained by electrolytic deposition. Both iron and cobalt in the *metallic* type possess magnetic rotary power four times as large as the electrolytic films, while the *dark* types exhibit a rotary power remarkably smaller than the electrolytic. The ellipticity imparted to the transmitted ray is affected to an equal degree.

Dark films of iron have an absorption region in the blue and in this region the magnetic rotation and ellipticity reverse their directions, as might be predicted from the characteristics exhibited by other substances possessing an absorption region in the visible spectrum. *Dark* films of cobalt show also interesting results in the visible spectrum, which duplicate in a sense the results from the iron.

Only *metallic* films of nickel could be obtained and these exhibited effects almost too small to measure.

The Electric Double Refraction of Carbon Bisulphide: Charles F. Hagenow, Armour Institute.

In insulating media subjected to an electric field, light waves vibrating in the direction of the field are propagated at a veloc-

ity different from those vibrating perpendicular to it. Kerr's law for the relative retardation of two such vibrations is given by the formula

$$\delta = B\ V^2 l/d^2$$

where V is the difference of potential between the two parallel plates of a plane condenser producing the field, d their distance apart, and l the length of path of the ray in the field. B is thus the constant of the dielectric used.

For different reasons it is important to determine this constant for carbon bisulphide. Previous investigators have found it to fluctuate over a range as high as twenty per cent. This paper deals with the treatment of the liquid necessary to reproduce results, and finally gives a series of careful determinations of B for various wave-lengths. Incidentally the results of Blackwell, showing that Kerr's law for the variation of the retardation with the wave-length is in error, are supported.

The Spectrum of Calcium: JAMES BARNES, Bryn Mawr College. (Read by title.)

The paper considers the changes produced in the intensity and distribution of light in the lines of the calcium spectrum obtained from an arc between metallic electrodes in air at atmospheric pressure and at lower pressures with varying current-strength. The results can be explained as a density effect rather than a temperature one.

The new triplets found by Saunders in a copper arc moistened with $CaCl_2$ appear very clearly and sharp when the arc is produced in a vacuum with a current of 12 amperes.

Many attempts were made to obtain true double reversals of the H and K lines with a steady arc, but without success. False multiple and double reversals appear in some of the other lines.

Upon the Magnetic Separation of the Spectral Lines of Barium, Yttrium, Zirconium and Osmium: B. E. MOORE, University of Nebraska.

Preston observed a similarity in the magnetic separation for spectral lines which formed similar series. Runge and Paschen confirmed this observation for a number of substances.

This research uses the magnetic separation of spectrum lines to search for series in cases where they have not been before observed. Runge used this method with barium.

The substances were volatilized by means of a spark in a strong magnetic field (24,400 c.g.s. units per sq. cm.) and photographed by means of a 21-foot grating. The components were separated by a calcite prism. Observations were made upon barium, yttrium, zirconium and osmium. A table was presented, showing an extended comparison between the author's results and some recently published by Runge.

The most prominent feature of the table is the fact that most of the lines of the substances here studied do not belong to the types which are represented in the well-known series groups. The next prominent feature is that the types are seldom duplicated. Thirdly, a great many types have common intervals, whose difference consists in a variety of the factors by which the interval must be multiplied to produce the actual separation. Fourthly, whether or not the intervals are aliquot parts of a normal interval a is not so decisive. It can easily be contended that the intervals are irrational fractions.

Fifthly, the Zeemann triplets offer no great advantages for the study of series unless the magnitudes of the separations separate into well-defined groups, as they do not in zirconium, osmium and yttrium.

Sixthly, series are eliminated from the

lines having several components except under quadruplets of zircon designated by interval $3a/8$. No series was found here.

An extended abstract of this investigation may be found in the *Physical Review.*

On the Absorption of Short Electric Waves by Air at Different Pressures: James E. Ives and R. E. Clyde Gowdy.

It has been known for some time that wireless telegraph messages can be sent farther at night than in the day. One explanation is that sunlight ionizes the air and this increases absorption.

To investigate this in the laboratory short electric waves were used, and were sent through a glass chamber in which the pressure could be varied. The waves were excited by a Righi oscillator 5 cm. long and received upon a thermo-junction made of fine iron and constantan wires. The intervening chamber was 44.5 cm. long, with plate-glass ends. Pressures were used ranging from .5 mm. of mercury up to 1 atmosphere. Two maxima of absorption and one minimum were found. One of the maxima is near zero pressure, the other between 40 and 60 cm. of mercury. The minimum lies between 25 and 35 cm. of mercury. The percentage absorption is not large, varying between $+7$ per cent. and -7 per cent. for the whole tube, or between $+.15$ per cent. and $-.15$ per cent. for each centimeter of its length.

The Magnetic Properties of Antimony: Arthur L. Foley, Indiana University.

Antimony can be made to exhibit either paramagnetic or diamagnetic properties by changing the temperature conditions under which it solidifies and crystallizes.

A Repetition of Wheatstone's Experiment of 1834: Francis E. Nipher, Washington University, St. Louis.

The paper gave reproductions of Wheatstone's figures in *Phil. Trans.,* 1834. It was pointed out that it seemed somewhat improbable that his mirror could have been given a velocity of 800 revolutions per second. The three sparks in a line half a mile in length were photographed. When Wheatstone's connections were used his result was not obtained. When one end of the line was grounded, the sparks always began at the gap nearest to the terminal of the machine and the others followed in consecutive order in time. The result was the same for the positive as for the negative discharge. With Wheatstone's connection the middle spark should appear last, but the result was so affected by distributed capacity that his result was not attained.

Determination of the Susceptibility of Copper and Tin and their Alloys: O. C. Clifford, University of Chicago.

By means of a torsion balance, hung symmetrically with respect to two magnetic poles and made diamagnetic by superposition of bismuth pieces, the variation of the force of repulsion upon the test pieces examined was measured. From the mechanical force thus determined and the constants of the magnetic field found with an exploration coil, the susceptibility of the specimens was obtained. Within a range of field strengths of from 200 to 600 lines, the bismuth gave the same susceptibility as had been found by other observers with much larger fields. By careful preparation tin was obtained which had a susceptibility of $+.31 \times 10^{-6}$. A very pure specimen of native copper was found to have a susceptibility of -1.22×10^{-6}. Alloys made from this tin and copper had susceptibilities which were in some cases of higher negative value than that of the copper, thus showing in diamagnetism a phenomenon altogether analogous to the Heusler phenomenon in paramagnetism. As the per cent. of tin increased from zero

to about that used in speculum metal, the diamagnetism increased to a maximum and then decreased, making the susceptibility of the alloy a complex function of the per cent. of tin and copper present. The maximum diamagnetic susceptibility of the alloys was about -2.1×10^{-6}.

A Satisfactory Form of High Resistance: G. W. STEWART, University of North Dakota.

There is an increasing demand for a satisfactory form of very high resistance. This paper makes record of a very convenient and satisfactory form of high resistance in which carbon is utilized, and also furnishes data concerning its constancy. Commercial lampblack mixed with a lacquer, "zapon L," is spread into films upon an insulating base. These films are permanent, are not subject to ordinary changes in temperature, do not evaporate, and do not crack. Such films are very easy to make, and can be given practically any range. The resistance temperature coefficient of such films when hard rubber is used as a base, is from 0.1 to 0.2 per cent.

Phonographic Record of the Doppler Effect: CHAS. T. KNIPP, University of Illinois.

In this paper an attempt was made to obtain a phonographic record of the Doppler effect. The phonograph was placed at the side of the track, and distant about thirty feet. The horn was directed toward the moving source of sound. A record was taken of a continuous blast of the locomotive whistle sounded over a distance of about 1,000 feet—500 feet on either side of the position of the observer. By simple calculation it can be shown that the pitch will be lowered one tone when the train velocity is 44 miles per hour or 64 feet per second. The train in question was moving at a velocity of 57 miles per hour or 84 feet per second. The pitch accordingly should be lowered 9.3/8 tones. The phonographic record when reproduced showed a distinct lowering of the pitch—fully a tone as far as it was possible to judge by the ear.

How does the Violinist control the Loudness of his Tone: HARVEY N. DAVIS, Harvard University.

One conclusion of the Helmholtz theory of the motion of a violin string does not seem to agree with experience, viz., that if the bowing point is fixed, the loudness of the tone depends wholly upon the speed of the bow and not at all upon its pressure. In explanation of this discrepancy, it is found that a certain pressure corresponds to each bowing speed, and that below this pressure the Helmholtz form of vibration can not be maintained.

The author is led to believe that the actual motion of a violin string is not usually of the normal Helmholtz type, but of the sort described in his paper a year ago as corresponding to light bowing. With the special apparatus devised it is possible to reduce the energy of the vibration to barely half its normal value, and the author hopes to be able to determine the limits of the sub-critical region for an actual violin and compare with them observations already obtained of the pressures ordinarily used.

A Wave Machine showing Damped or Undamped Compound Waves: ALBERT B. PORTER. (Read by title.)

This machine compounds two harmonic waves either or both of which may be of constant amplitude, may have any desired damping coefficient, or may increase in amplitude at any desired rate. It thus serves not only to illustrate the ordinary problems in simple harmonic motion, but also the effects of damping by frictional or

other resistance, and the phenomena of resonance.

The machine offers nine choices of ratio of periods between the two simple waves, and each of these ratios may be thrown slightly "out of tune" for the purpose of showing beats, or the changes in the compound wave and the evolutions of the Lissajous figure as the phase progressively changes. There are three choices of wavelength of the fundamental wave. The amplitude of either wave may be given any value between zero and the maximum permitted by the size of the machine; the phase difference can be varied between 0° and 360°; and either wave may be given any desired positive or negative damping coefficient.

Notes on Harmonic Analysis: Albert B. Porter. (Read by title.)

This paper describes: (1) A geometrical representation of the Fourier coefficients of a periodic function as a series of solids; (2) the essential mechanism of an integrating harmonic analyzer which is based on this representation; (3) a new method of harmonic analysis by use of specially ruled sine-coordinate paper, on which the given function is plotted, and the Fourier coefficients are determined by measurement with an ordinary planimeter, and (4) a modified form of the Yule analyzer.

Some Experiments on the Radioactivity of Potassium Salts: J. C. McLennan, University of Toronto.

In this paper an account is given of some experiments which confirm the discovery by Campbell and Wood that potassium salts emit a radiation of high penetrating power.

In the first series of measurements some chemically pure potassium sulphate was spread into a thin layer and placed close to and beneath an ionizing chamber 40 cm. long, 26 cm. wide and 28 cm. high. The bottom of this vessel was closed with a fine-meshed gauze which permitted the radiation to pass through. The saturation currents were measured with a quadrant electrometer.

In the first set of measurements different areas of the salt were exposed, and it was found that the radiation emitted was directly proportional to the free surface of the salt.

In a second series of measurements a layer of the salt 35 cm. by 18 cm. was placed under the ionizing chamber, and then gradually lowered, thus altering the air column traversed by the radiation before it entered the chamber. The results of this experiment show that it was necessary to lower the layer of salt some 17.5 cm. before the saturation current was reduced one half. With the salt at a distance of 42 cm. from the chamber, the ionization current was still approximately considerable, being one tenth of its highest value. In a third series of measurements a layer of the salt was again placed beneath the ionization chamber, and the absorption of its radiation studied by covering it successively with an increasing number of sheets of tin-foil, and at the same time measuring the corresponding saturation currents. The tin-foil used in these measurements was .0089 mm. in thickness. It was found that the saturation current diminished from 188 to 10 units as the number of sheets of tin-foil were increased from 0 to 32. Seven sheets reduced it to one half its value.

The fourth series of measurements was made with the object of ascertaining whether this radiation from potassium salts, which from its characteristics evidently consisted of β or γ rays, was due to some property possessed by the salt intrinsically, or whether it was due to a secondary radiation excited in the salt by the penetrating rays from the earth.

From the experiments described it is clear that the effects produced were due to a primary activity possessed by the salt and not due to a secondary activity imparted to it.

On Variations in the Penetrating Radiation from the Earth: C. S. WRIGHT, University of Toronto. (Communicated by Professor J. C. McLennan.)

In this paper the author gives an account of some measurements made on the penetrating radiation from the earth in different localities on the north and south shores of Lake Ontario, and also at different points on the surface of the lake during the passage over it by steamer.

In making these measurements observations were taken by means of an electroscope of the improved Wilson type on the saturation current through the air in a closed lead cylinder.

The following statement contains a summary of the results. In this table the conductivities are corrected for variations in temperature and pressure, and are expressed for purposes of comparison by the number of ions generated per c.c. per second within the cylinder at the different points of observation.

TABLE OF CONDUCTIVITIES

Observation Stations	No. of ions generated per c.c. per second within the lead cylinder
First Set of Observations	
Physical Laboratory, University of Toronto	22.5
At edge of harbor waters (30 meters from shore) (filled-in ground)	19.3
South end of breakwater at Eastern Gap (water 4 meters deep)	14.1
On sand spit between lake and harbor (110 meters from shore)	14.26
On ground floor Canoe Club, at end of pier in harbor (water under floor 6.5 meters deep)	13.5
Second Set of Observations	
Old Physics Building, University of Toronto	23
New Physics Building	22
On board steamer *Corona* at dock	18
At different points between Toronto Harbor and Niagara River bell buoy	18.9, 18.8, 19.1, 18.3 (av. 18.8)
At Niagara dock	20
Niagara River, Paradise Grove	18.2
Queenston Heights	23.3
Niagara Falls Park	22.9
Elevator Shaft, Ontario Power Co., Niagara Falls (40 meters under ground)	22.6
At foot of Niagara Falls	20.3

A Null-reading Instrument for the Measurement of Ionization: S. J. ALLEN, University of Cincinnati.

A Comparison of the Formulas of Helmholtz and of Nernst for the E.M.F. of Concentration Cells: H. S. CARHART, University of Michigan.

The Stability of Cadmium Cells: H. S. CARHART, University of Michigan.

On the Separation of Echelon Spectra by Gratings: A. A. MICHELSON, University of Chicago.

Selective Reflection as a Function of the Atomic Weight of the Base: W. W. COBLENTZ, Bureau of Standards, Washington. (Read by title.)

The Infra-red Absorption of Certain Biaxial Crystals for the Three Principal Directions of Vibration: R. E. NYSWANDER, Cornell University.

New Physical Aids to Navigation: H. E. WETHERILL, Philadelphia. (Read by title.)

The Distribution of Energy in the Spectrum of the Tungsten Filament: R. E. NYSWANDER, Cornell University. (Read by title.)

The Use of Complex Quantities in Alternating Currents: G. W. PATTERSON, University of Michigan.

Physical Research at a Mountain Observatory: G. E. HALE, Mt. Wilson Observatory.

Some Curious High-temperature Phenomena: C. E. MENDENHALL, University of Wisconsin.

ALFRED D. COLE,
Secretary

VASSAR COLLEGE

SCIENTIFIC BOOKS

The Origin of a Land Flora: A Theory based upon the Facts of Alternation. By F. O. BOWER, Sc.D., F.R.S., Regius Professor of Botany in the University of Glasgow. With numerous illustrations. 8vo, pp. xii + 727. Macmillan and Company, Limited. St. Martin's Street, London, 1908.

The author of this book is well known to American botanists as the writer of many lucid articles, and especially as the propounder of a very helpful theory as to the nature of the flower and its relation to the remainder of the sporophyte. When Professor Bower published his "theory of the strobilus" (*Annals of Botany,* Vol. VIII., 1894, p. 343) he made a contribution to morphology which at once marshaled the floral and foliage structures of higher plants in accordance with the doctrine of evolution, and destroyed the time-honored theory of the metamorphosis of foliage leaves into the perianth and essential organs of the flower. In the light of this theory the origin of the flower is no longer the hazy, although plausible impossibility of the older text-books. That he swept away along with much accompanying rubbish, and in its place gave us an explanation which has the double merit of agreeing with observed facts, as well as being biologically possible. Now the author who gave us a rational theory of the origin of the flower appears with a volume devoted to the origin of the terrestrial habit in plants, or as he puts it in the title of his book—the origin of a land flora—and we may predict for this later theory a history equally successful with the former.

The volume consists of forty-seven chapters, divided into three parts, the first (of twenty chapters) being devoted to a "statement of the working hypothesis," the second (of twenty chapters, also) including a "detailed statement of facts," and the third (of seven chapters) devoted to "conclusions." Starting with the accepted doctrine of biologists that animal and plant life originated in the water, he shows that it is the sporophyte generation which becomes terrestrial, while the gametophyte is wholly aquatic, or at best still greatly dependent upon an abundant supply of water. His statement (p. 244) is so clear that we quote it here verbatim: "In respect to their whole life-cycle the *Archegoniatae* may be said to show an amphibial existence, the aquatic and the terrestrial characters being reflected in its two alternating phases. The gametophyte is as a rule delicate in texture, without intercellular spaces in its tissues, or a fully developed water-conducting system, while its sexual organs only become functional on their rupture in water outside the plant-body: the gametophyte thus proclaims its ultimate dependence on external fluid water as thoroughly as an alga. The sporophyte, on the other hand, is a characteristically subaerial body; this is shown by its more robust habit, its effective ventilating system, and its vascular strands for the conducting function seen in the higher forms: its final result, the maturing and dissemination of spores, is normally carried out under circumstances of dryness. All these features mark it as an essentially terrestrial phase."

In Chapter V. the author discusses the cytological differences between the gametophyte and sporophyte first distinctly pointed out by Strasburger in 1894, accepting chromosome-reduction as marking the end of the sporophyte generation and the beginning of the gametophyte, and chromosome-doubling as the end of the gametophyte generation and beginning of the sporophyte. By applying this test the beginnings of an alternation of generations may be recognized cytologically in the

vegetable kingdom long before it becomes obvious morphologically.

In the final chapter, which is entitled "Results, Phyletic and Morphological," some of the conclusions may be quoted, as "Both Mosses and Liverworts may with probability be held to be blind branches of descent, which illustrate nevertheless phyletic progressions that illuminate the origin of sterile tissues from those potentially fertile, and the establishment of a self-nourishing system in the sporophyte." "The phyletic relationship of the *Sphenophyllales* and *Equisetales* has undoubtedly been a very close one; the distinguishing features are not to be found in the primary plan or construction of the shoot, so much as in the secondary modifications of number and relation of the appendages, and of their branching, together with changes in the originally protostelic structure of the axis. Such considerations support the conclusion that the Sporangiophoric Pteridophytes constitute a brush of naturally related phyletic lines." "The Filicales appear as the most divergent phylum of homosporous Pteridophytes." Speaking of the vegetative system of the sporophyte in higher plants the author says: "Taking an evolutionary course of its own it diverged more and more in character from the propagative system. The final result is seen in the Angiosperms which are now dominant: here the flowers differ widely from the vegetative shoots, though the plan of each resembles that of the primitive shoot from which both sprang. But whatever the modern complications may be, comparison along lines which have been pursued in this volume indicates that the sporophyte, which is the essential feature in the flora of the land, is referable back in its origin to post-sexual complications: it appears to have originated as a phase interpolated between the events of chromosome-doubling and chromosome-reduction in the primitive life-cycle of plants of aquatic habit."

It merely remains to say that the publishers have brought out the book in a style befitting its importance—paper, type, presswork and illustrations, all being good and pleasing to the eye. The illustrations, of which there are 361, are plain, and while no attempt has been made to secure artistic effect, they do what they were intended to accomplish—namely, they help to explain the subject-matter. It is in all ways a thoroughly satisfactory book.

CHARLES E. BESSEY
THE UNIVERSITY OF NEBRASKA

Monographie des Onychophores. By E. L. BOUVIER. Extracted from *Annales de Sciences Naturelles, Zoologie* (1907), pp. 383 + 318, Pls. XIII.

The splendid monograph of the Prototracheata recently published by Professor Bouvier of the Paris Museum deserves a rather extended notice, because of the great interest attaching to the group of which it treats, and the fact that the work, owing to its place of publication, is very little known to American naturalists. A most interesting preface is headed by an appropriate motto, taken from Albert Gaudry: "Vieux habitants de la terre, apprenez-nous d' où vous êtes venus." A section follows, containing a general account of the morphology of the animals, with no less than 44 new and admirable text-figures. The bulk of the book is, of course, occupied with the detailed descriptions of the genera and species, while at the end are a complete bibliography and a check list. Everything is worked out in the most complete manner possible, and the history of each species is fully narrated; in its careful attention to detail and arrangement, the monograph may be classed with Scudder's great work on the butterflies of New England and Taylor's "Monograph of the British Land and Freshwater Mollusca."

The history of the classification of the Prototracheata is interesting. Up to 1894, all the known species were referred to the genus *Peripatus,* but in that year Pocock, in spite of opposition, recognized three genera, two proposed by him as new. This was thought revolutionary at the time; but to-day Professor Bouvier describes two families and seven genera, with excellent characters! The number of species has been increased from a mere handful to fifty, nineteen of them described by Professor Bouvier. The group remains as

isolated as ever, and its distribution is still disconnected, indicating great antiquity and partial extinction. The Peripatidæ include two genera, *Peripatus* and *Eoperipatus*. The former is neotropical, with the exception of a single species (*P. tholloni*) found in the French Congo. The latter consists of three species, two from Malacca, the other Sumatran. Thus the distribution is not unlike that of the tapirs, and we should look for fossil remains in the Tertiary beds of the Palæarctic and Nearctic regions, were not the preservation of *Peripatus* in this manner so unlikely. The African species may possibly be explained by an accidental passage (*e. g.*, on a floating tree) across the Atlantic, rather than as indicating an ancient land-bridge, or a long migration via Asia or Europe. It is noteworthy, however, that in certain respects it approaches the Malayan *Eoperipatus*, so that it would be possible to regard the latter as having reached Asia by way of Africa, the *Peripatus* of the latter continent remaining as a relic of a very ancient route of migration.

The genus *Peripatus*, as now understood, is divided into three groups or subgenera, as follows:

(1) *Oroperipatus* n.n.; "Péripates andicoles." 12 species. Type *P. lankesteri* Bouvier.

(2) *Peripatus* s.str.; "Péripates caraïbes." 17 species. Type *P. juliformis* Guilding.

(3) *Mesoperipatus* Evans; "Péripates africains." 1 species. Type *P. tholloni* Bouvier.

Professor Bouvier does not use any subgeneric names; I have ventured to supply one for the Andicolous group. This appears to be the most primitive of the three, and might better be considered typical *Peripatus*, had not the name been first applied to a Caribbean species.

The distribution of the two neotropical groups is exceedingly interesting, one being characteristic of the Andean chain, the other of the more eastern regions and the West Indies. *Oroperipatus* has three species in Bolivia, six in Ecuador, one in Colombia, and finally enters Mexico on the *west* side, getting as far north as Tepic (*P. eiseni* Wheeler). The subgenus *Peripatus* has nine species and subspecies in the West Indies, two in the coast region of Brazil, five in the Guianas, three in Venezuela, one each in Costa Rica and Nicaragua, and reaches Mexico on the *east* coast, extending to Vera Cruz. If we think of the two subgenera as reaching Central America by way of the isthmus of Panama, it is not at first apparent why they should have carefully kept to the same two sides of the country they occupied in the southern hemisphere. It is to be remarked, however, that *P. eiseni* is a mountain species, occurring at an altitude of 4,000 feet, and so its ancestors doubtless followed the Andean chain; whereas the Caribbean types probably clung to the coast line, and consequently to the east. Whether through Tertiary time these animals were widely distributed over North America, or whether they reached that continent only at the time when the isthmus rose above the sea and permitted the ingress of various well-known neotropical genera, must for the present remain uncertain.

The details of the distribution of the West Indian species are worth investigating. There are apparently no species in Cuba and the Bahamas, and none have been described from Hayti, though they may be expected there. The lesser islands are populated by various forms of the *P. juliformis* type, and Professor Bouvier has shown that the Jamaican forms, which I formerly regarded as variations of a single species, really represent two, the so-called *P. jamaicensis swainsonæ* Ckll. being in fact a member of the *juliformis* series. It is indeed so close to *juliformis* that Bouvier makes it a variety of that species, though in view of its isolation I should prefer to treat it as a species, *P. swainsonæ*. It is practically certain, no doubt, that *P. swainsonæ* reached Jamaica from the east, along the chain of islands; but it seems probable that the other species, *P. jamaicensis*, reached the island (along with *Capromys* and other animals) from Central America, by way of a land bridge or chain of islands now represented by large areas of shallow water. Professor Bouvier, to whom I communicated this suggestion, agrees with me that it is probably correct; it has the advantage of accounting

for the absence of any close relatives of the very distinct *P. jamaicensis* in the other West Indian islands.

The Peripatopsidæ, with five genera, are no less interesting. They are confined to the southern hemisphere, with the following distribution:

Paraperipatus Willey. 1 species. New Britain.

Peripatopsis Pocock. 6 species. S. Africa.

Opisthopatus Purcell. 2 species; one Natal, the other Chili!

Peripatoides Pocock. 4 species; two in New Zealand, two in Australia.

Ooperipatus Dendy. 4 species; one in New Zealand, one in Tasmania, two in Australia.

The case of *Opisthopatus* is most remarkable, though similar instances are known among insects. The Chilian *O. blainvillei* may be imagined to represent the last relic in America of the Peripatoid fauna of von Ihering's Archhelenis, a continent supposed to have once connected Africa with South America. This would mean that the genus *Opisthopatus*, though severed into two widely-separated parts, has retained its essential characters throughout Tertiary time.

The classification of the Australian and New Zealand species is not quite satisfactory. Professor Bouvier shows, or at least gives very good reasons for believing, that *Ooperipatus oviparus* is not genetically related to the other three species of the genus, but represents an independent development of oviparity from *Peripatoides* stock. Hence it would appear necessary to make *O. oviparus* the type of a new genus, to follow *Peripatoides* in the list. The Tasmanian species is called by Professor Bouvier *Ooperipatus insignis* Spencer and Dendy; but since it is not the earlier *P. insignis* Dendy, it must have a new name.

T. D. A. C.

SCIENTIFIC JOURNALS AND ARTICLES

IN *The American Naturalist* for January T. H. Morgan describes some "Experiments in Grafting" undertaken primarily with a view to finding out whether or not it is possible by artificial means to induce regeneration in a part that does not ordinarily regenerate. For example, a part of a lizard's tail was grafted on the stump of a leg, the idea being that the stimulation of the tail portion, which does regenerate, might induce regeneration in the limb. The results, however, are so far negative. Charles A. White discusses "The Phenogamous Parasites" and C. William Beebe gives a "Preliminary Report on the Investigation of the Seasonal Changes of Color in Birds," noting the influence of warmth and moisture. A. H. Wright and A. A. Allen have "Notes on the Breeding Habits of the Swamp Cricket Frog, *Corophilus triseriatus* Wied," and Adam Hermann describes "Modern Methods of Excavating, Preparing and Mounting Fossil Skeletons," methods which have probably reached a higher degree of perfection in this country than in any other and which Mr. Hermann himself has done so much to develop. John T. Gulick considers "Isolation and Selection in the Evolution of Species: The Need of Clear Definitions," pointing out that the above terms, as well as environment and even evolution, are used by different writers in a varying sense.

The Museums Journal of Great Britain for February opens with an article by James Duncan, on "Experience of Sunday Opening at Dundee," the matter being deemed of special importance because it is the most northern museum in "Sabbath-keeping" Scotland to open its doors on a Sunday. The results have been eminently satisfactory. There is a brief description of "The Royal United Service Museum" and, under "Museum Notes," F. W. Fitz Simons suggests that the round, perforated stones from Africa, known as Bushmen's stones, may have originally been symbols of Phallic worship.

The American Museum Journal for March has as frontispiece a reproduction of Eastman Johnson's portrait of the late Morris K. Jesup, taken in 1892. It is noted that a special publication will give an account of Mr. Jesup's life and service to the museum. There are articles descriptive of the "Bismarck Archipelago Collection," the "South American Blow-gun" and the "Exhibition showing the Congestion of Population in New York City."

This exhibit is shortly to be transferred to Brooklyn.

The Bulletin of the Boston Society of Natural History for March gives notice of the coming meeting of the geologists and mineralogists of the northeastern section of the United States, to be held in New York, April 6. It also gives a description of the botanical collection of the society and the work in its development.

Leaflets Listing and Describing Birds of Oregon may be added to the ever-increasing number of publications whose intent is to furnish information as to the habits and value of birds and the desirability of protecting them. These just mentioned are intended largely for use in the public schools. No. 1, by William L. Finley, treats of the "Study of Birds and Their Economic Value"; No. 2, by the same writer, tells of "Some Common Birds of Oregon with Notes on their Economic Value."

SOCIETIES AND ACADEMIES

THE SECTION OF GEOLOGY AND MINERALOGY OF THE NEW YORK ACADEMY OF SCIENCES

The regular monthly meeting of the Section of Geology and Mineralogy of the New York Academy of Sciences was held on Monday evening, January 6, 1908, at the academy rooms in the American Museum of Natural History, New York City.

The section authorized the officers to arrange for a joint meeting of sections and departments of geology and mineralogy from neighboring academies, museums, surveys and colleges to be held in April. Invitations are being prepared and will be distributed through New England and the Middle Atlantic States.

Two papers were presented, the titles and abstracts of which follow.

A Revised Classification of the North American Siluric System: Amadeus W. Grabau.

A review of the successive modifications of the classification of the Siluric system in North America brings out the fact that the process of refining has been largely by separation off from this system of those divisions not properly belonging to it. Thus Dana in 1863 (first edition of the "Manual") included the Ordovicic and Cambric as Lower Silurian, dividing it into Potsdam, Trenton and Hudson, and dividing the Upper Silurian into Niagara, Salina and Lower Helderberg. In the fourth edition of the "Manual" (1895) the Cambric, Ordovicic and Siluric systems are recognized as distinct, though the name Lower Silurian is still preferred for the Ordovicic. The three-fold division of the Siluric is into (1) Niagara, (2) Onondaga (Salina), and (3) Lower Helderberg. In 1899 Clarke and Schuchert published their revised classification of the New York series, which has been pretty generally adopted. In this the Helderbergian exclusive of the Manlius was separated as Lower Devonic, while the remainder of the Siluric (Niagara and Onondaga (Salina), of Dana, 1895) was divided into the Oswegan (Oneida Conglomerate-Shawangunk grit and Medina sandstone), Niagaran (Clinton, Rochester, Lockport and Guelph), and Cayugan (Salina, Rondout and Manlius). Since then Grabau and Hartnagel have independently demonstrated that the Oneida is the equivalent of late Medina, and the Shawangunk, Salina. In 1905 Grabau suggested the Richmond age of the lower 1,100 feet of the Medina of Western New York,[1] uniting the upper with the Clinton. These relations were more fully discussed in 1906[2] and again in 1907 before the Geological Society of America, New York meeting, after a prolonged investigation of the Appalachian deposits. This relationship is now fully established and the dividing line between Ordovicic and Siluric is drawn at the base of the Upper Medina or the Medina proper. For the red Medina shales now recognized as of Ordovicic age the name Queenston beds is proposed, from the town of that name on the Niagara River opposite Lewiston, where these beds are partly exposed.

Recent studies by Grabau and Sherzer in southern Michigan and adjoining regions in Canada and Ohio have demonstrated the existence of about 900 feet of fossiliferous strata above the Salina, to which it is proposed to restrict the name Monroe. These will be fully

[1] Science, XXII., p. 529, October 27, 1905.

[2] Bull. 92 N. Y. State Museum.

discussed in a forthcoming memoir, where the correlation of the eastern attenuated Upper Siluric beds will be given. The fauna of the Upper Monroe above the Sylvania sandstone is a remarkable mixture of Siluric and Devonic types as recently demonstrated before the Michigan Academy of Sciences, the Chicago meeting of Section E, American Association for the Advancement of Science and the Albuquerque meeting of the Geological Society of America.

The following classification of the Siluric System of North America is proposed as most expressive of the relationships indicated by the facts now known.

Upper Siluric or Monroan (900 ft.)	Upper Monroe. Middle Monroe (Sylvania sandstone the only known representative). Lower Monroe.
Middle Siluric or Salinan (1,000 ft.)	Represented so far as known only by non-marine sediments.
Lower Siluric or Niagaran (500–1000 ft.)	Guelph (possibly to be placed with Middle Siluric). Lockport dolomite. Rochester shales. Clinton: Clinton shales and limestones. Clinton: Medina sandstone including Oneida conglomerate.

Ordovicic—Queenston shales.

A Study of the Mineral Constitution of the Chloritic Group Termed Delessite: ALEXIS A. JULIEN.

In regard to the constitution of minerals and mineral micro-aggregates, as in rocks, it is entirely insufficient and often misleading to depend upon chemical analyses alone, or upon formulæ deduced therefrom, although commonly this is all that is supplied in the treatises. In place of these, a calculation of the actual mineral constitution of the aggregate through a recasting of the analyses is required for the needs of the mineralogist or petrographer. All are mixtures. Even the best crystallized mineral has definite mineral impurities. From the well-crystallized form to the amorphous compact mass, in which only the microscope can perhaps barely detect the structures and optical behavior of obscure crystalline conditions—all are mineral mixtures. For each group of minerals under such investigations it is found advisable to prepare a tabulated scheme comprising all possible mineral constituents, together with their percentage composition. Using this, on the assumption of absolute accuracy of the certainly determined mineral formulæ, allowing for the limitations of replacement inherent in each mineral as far as known, and making careful correlation with the ascertained physical and optical characteristics of the identical mineral or micro-aggregate, its mineral constitution can be deduced with satisfactory accuracy.

In illustration, this simple method has been applied to a most complex group of micro-aggregates, many of which now pass as definite mineral species—the delessite group. It will suffice here to give one example covering the hitherto accepted mineral "delessite" itself. The analysis is of material from Zwickau by Delesse.

	Per Cent.
Silica, SiO_2	29.45
Alumina, Al_2O_3	18.25
Ferric oxide, Fe_2O_3	8.17
Ferrous oxide, FeO	15.12
Lime, CaO	0.45
Magnesia, MgO	15.32
Water, H_2O	12.57
Total	99.33

In explanation we are informed by Dana: "Comp.—Perhaps (Groth) $H_{10}(Mg, Fe)_4(Al, Fe)_4Si_4O_{25}$." By using, however, the theoretical percentage composition of each of the minerals stated below, in harmony with the description of "delessite," the figures of this analysis will be found to correspond to a mere mixture with the following mineral constitution:

	Per Cent.
Prochlorite	72.13
Halloysite	10.34
Limonite	9.54
Colloid silica with water	7.32

By similar calculations the constitution of

the whole delessite series has been approximately brought to light. The paper will be published in full in the *Annals* of the academy.

CHARLES P. BERKEY,
Secretary of Section

THE BIOLOGICAL SOCIETY OF WASHINGTON

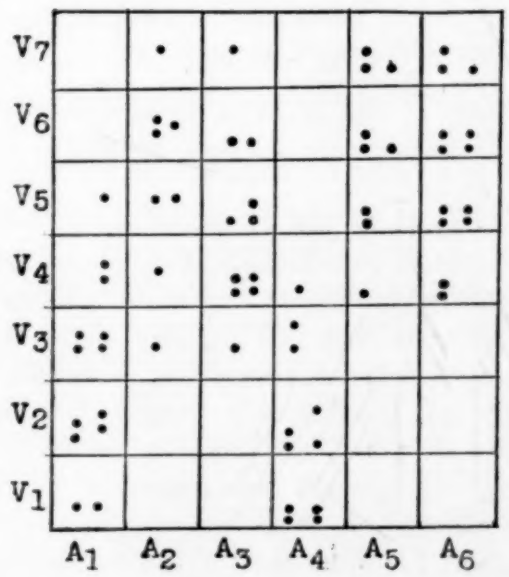
THE 441st meeting was held on March 7, 1908, President Stejneger in the chair.

Mr. H. W. Clark noted a case of fasciation in two specimens of hyacinth seen in a Washington market. The flattening of the flower stalk gave a larger floral surface and made it conspicuously showy. The bulbs of these flowers were said to be imported from Holland and new stock was asexually propagated from lateral tubers. This is the beginning of a new and very showy stock of cultivated plants probably worth developing. Fasciation is a unique and remarkable phenomenon in the history of cultivated plants, and occurs frequently in such plants as the sweet potato and yam which are cultivated asexually. In the cultivated cockscomb (*Celosia*) it is propagated by seed. Among our native plants it is common in *Œnothera,* and occasional in *Leptilon* and the sumacs. It is also common in the imported *Ailanthus.*

Professor W. P. Hay by request demonstrated "Some Additional Colored Lantern Slides by the Autochrome Process." He showed on the screen many colored pictures, illustrating the possibilties, difficulties and defects of the autochrome process. He explained the technique of the process, calling attention to the difficulties in handling the plates and the differences between autochrome and ordinary photography.

Mr. Vernon Bailey gave a lantern-slide lecture on "Home Life of the Lobo or Buffalo Wolf of the Great Plains." This was an account of the observations of the speaker on the large or timber wolf of the western plains, undertaken partly to learn to what extent the forests harbored these wolves. Forest reserves have been opposed with the argument that the wolves breed in them. Mr. Bailey found wolf dens in the open and on the edge of the forest reserve, but none in the timber. He described the habits of the wolves and their wary avoidance of attempts to trap them and showed many photographic lantern slides of the dens, the young, and of the wolf country.

Dr. Marcus W. Lyon, Jr., read a paper, describing and illustrating "A Simple Method to Represent Graphically the Trend of Variation in a small number of Specimens of Related Species." Where there is but a small number of individuals in a group of related organisms, A_1, A_2, etc., to be examined, the usual curves representing the extremes of variation with the average at the highest part of the curve, do not give satisfactory results as the curve will present too many irregularities and sometimes show no distinct maximum for the average. A modification of the regular coordinate system may be used, however, to represent graphically the extent and trend of variations, V_1, V_2, etc., by running a series of parallel lines at right angles to the vertical axis, the space between the lines corresponding to the variable character, with its least development at the level of the horizontal axis and its increasing development at regular intervals above it. The horizontal axis is similarly divided by a series of parallel lines, the space between any two lines corresponding to the groups of the organisms under consideration. To allocate the individuals with respect to the variations it is only necessary



to examine each specimen in turn and place a dot in one of the small squares made by the

intersections of the parallel lines, which corresponds to its proper group and the extent of its variation. The resulting system of dots shows at a glance the extent and trend of the variations in any of the groups, and in a much more graphic manner than an examination of the specimens, or tables of measurements, or descriptions.

In the diagram, groups A_1 and A_4 show the possession of similar characters, groups A_2, A_3, A_5 and A_6 possess another set of characters. Some specimens in each group show an overlapping of characters or intergradation. The two major groups thus show a subspecific relation to each other.

M. C. MARSH,
Recording Secretary

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

THE 648th meeting was held March 28, 1908, President Bauer in the chair.

Dr. C. G. Abbot presented a paper entitled "Total Eclipse Observations of January 3, 1908," giving an illustrated account of his trip to Flint Island in the south Pacific Ocean, via California and Tahiti, for the purpose of observing the recent solar eclipse. His principal object was to ascertain the comparative brightness of the solar corona and the sun, and to compare the quality of the radiation of the corona with that of the sun, the moon and the sky. He was successful in measuring the brightness of the corona at five points with the bolometer, and by interposing a screen of asphaltum varnish determined roughly the proportion of its radiation which falls in the visible spectrum. At brightest the corona was little more than 1/1,000,000 as bright as the sun, but the quality of its radiation as tested by the asphaltum screen differed little from that of the sun. The results are perhaps best explained by considering the corona to shine mainly by reflected sun rays.

Informal Communications

Professor C. F. Marvin spoke of the seismograph records of the recent Mexican earthquake (March 26, 1908) which had been obtained from the Omori and Marvin types of seismographs at the U. S. Weather Bureau, and pointed out significant differences in the amplitudes and the character of the wave motion as recorded by the two forms of instrument which were installed under exactly similar conditions.

The secretary read a communication prepared by Professor Cleveland Abbe, giving the following abstract of the results of a computation, by Professor H. A. Peck, of Syracuse University, of the orbit of the meteor of Christmas eve, 1873, based on the data in the report of the meteor committee.[1]

First, the point of *disappearance* was determined from records at four of the best observing stations, following the method given by Bauschinger. The resulting location is:

Longitude, 0° 57.8′ west of the dome of the capitol.
Latitude, + 38° 42′.
Altitude, between 5 and 9 miles—the mean of which, 7 miles, is adopted.

With this determination as a foundation the position of the radiant point was determined by the method of least squares from the observations at twelve good stations. The result is:

A (right ascension of radiant)	66° 55′
D (declination of radiant)	+ 29° 51′

This last result may be otherwise expressed thus: The bearing and apparent angular altitude of the radiant point, as seen by an observer *at* the point and moment of disappearance, would be

Azimuth	S. 86° 55′ E.
Altitude	56° 27′

The first appearance of the meteor, or the beginning of its visible path, may plausibly have been at about 130 miles above a point in latitude 38.6°, longitude 76.3°, or above the mouth of the Choptank River, Maryland. The corresponding length of the visible path would be 154 miles and the velocity relative to the earth's center 38.5 miles per second.

The computation of the path relative to the sun and the ecliptic gives the true radiant point:

Longitude	(λ)	50° 47′
Latitude	(β)	+ 6° 26′
Velocity		50 miles per second.

[1] *Bull. Phil. Soc.*, 1877, Vol. II., pp. 139–161.

The meteor was following and overtook the earth, the angle between its path and the direction toward the apex of the earth's motion being 132°. The elements of the orbit with reference to the sun are:

Ω	273° 22′	longitude of ascending node.
i	9° 28′	inclination to the ecliptic.
π	150° 12′	longitude of the perihelion.
$\log q$	9.7937	logarithm of the perihelion distance.
$\log e$	0.6329	logarithm of the eccentricity.

Professor Peck's paper will be printed in full in the *Monthly Weather Review*.

R. L. Faris,
Secretary

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the meeting of February 18, Miss Frances Densmore read a paper entitled "Music of the Chippewa," and used as illustrations many phonographic records secured by her during a season's work for the Bureau of American Ethnology among the Chippewa of Minnesota. Miss Densmore said that the music of the Chippewa is an echo from the land of the pine trees, the lakes and the little hills. All their life is intertwined with music; from babyhood to death the songs of the people express the joys and sorrows of life, the exultation of war, the solemnities of their religion, the tenderness of love and the cradle songs, farewells to the warrior and dirges for the departed. Miss Densmore gave a cradle song, the invitation to a ceremony, a plaintive love song, the requiem of Chief Flatmouth, the song of Wain-ah-bo-zho (who wrung the ducks' necks), and a series of songs of initiation into the Grand Medicine Society, which latter ceremony was described in some detail. At the close of Miss Densmore's paper three Chippewa Indians visiting Washington gave a representation in costume of the initiation of a candidate for membership in the medicine lodge, and the effect of the songs accompanied with the rattle and tom-tom was very striking. The chief also made a speech laudatory of his white friends in Washington, Rev. J. W. Gilfillan interpreting. The paper was discussed by Miss Fletcher and Mr. Wead, and Miss Densmore answered a number of inquiries.

Walter Hough,
General Secretary

DISCUSSION AND CORRESPONDENCE

TOXICITY AS A FACTOR IN THE PRODUCTIVE CAPACITY OF SOILS

The U. S. Department of Agriculture in 1903 promulgated, through its Bureau of Soils, in Bulletin 22, the teaching (1) that practically all agricultural soils contain sufficient plant food for good crop yields and that this supply will be indefinitely maintained; (2) that not only is the soil moisture a natural nutritive solution, but that it has sensibly the same concentration in productive and unproductive soils; (3) that this concentration is by natural processes constantly maintained of sufficient strength to meet the needs of crops giving good yields; and (4) that the good effects observed in all parts of the world to follow the practise of proper rotation of crops, the application of stable and green manures and of mineral fertilizers, must be due to some other mode of action than that of supplying the crop on the ground with needed additional plant food.

During the four years since the publication of these views the Bureau of Soils has devoted much of its time, energy and funds to an attempt to show (1) that crops excrete through their surfaces, and leave in the soils or upon the field toxic substances which, when tilth and climatic conditions are right, are the chief cause of reduced yields and runout lands; and (2) that proper crop rotations, stable and green manures and mineral fertilizers owe their observed good effects on crop yields to destroying or removing these toxic principles rather than to contributing plant food to the crops.

In the support and promulgation of these views there have now been published four other bulletins from the Bureau of Soils and one circular from the office of the Secretary of Agriculture in reply to adverse criticisms made upon them. It is the purpose here to discuss broadly but concisely what basis there may be for these views.

Amount of Plant Food Carried by Soils.

When no distinction is made between the amount of *plant food proper* and the amount of the elements and substances from which

plant food may be derived there is no doubt but that the amount present, even in the poorest soils, is very large when measured in units of yearly crop demands. But the amount is not so large, either absolutely or in the rate of renewal by rock weathering, as to be inexhaustible if only it could be made continuously available at the rate required for good yields. Indeed the untruth of an assertion that by establishing good mechanical facilities for a high rate of removal of coal and thorough sanitary conditions for the miners, the supply of coal in a given mine will be indefinitely maintained, is no more certain than the contention that by a proper rotation of crops and the maintenance of good tilth and proper sanitary conditions uniformly large yields may be indefinitely maintained on any and all fields without a return to the soil of the plant food removed. We have in Wisconsin residuary soils whose absolute content of potassium is only 4.6 tons, of calcium 5.3 tons, of magnesium 3 tons, of nitrogen .9 ton and of phosphorus .8 ton per acre-foot of field. But it is very important to recognize that by very far the larger proportion of these plant food elements existing in the soil is, properly speaking, no more to be regarded as plant food for the crop growing upon the ground than it is food for the cattle feeding upon pasture grass, hence there is never present in the soil of a field any such large amounts of plant food proper as have been stated.

But, considering these amounts as capable of being converted into plant food proper as rapidly as large yields of crops would demand, the whole amount of the phosphorus finds its equivalent measure in the amount carried in 268, and the whole of the potassium in but 634, 20-bushel-per-acre crops of wheat, allowing nothing for losses by leaching. And yet the rate of surface erosion which will expose uncropped material from below as rapidly as one foot in 4,000 years could supply phosphorus only one fifteenth and potassium one sixth as fast as would be demanded by the 20-bushel crops of wheat. It follows, therefore, that for the soil in question to have a productive capacity of 20 bushels per acre per annum, indefinitely maintained without the application of phosphorus and potassium, the rate of surface erosion and of subsoil and rock weathering must equal one foot in every 268 years for the phosphorus, and one in every 634 for the potassium. But these are rates seldom if ever experienced in any agricultural region and the mean rate of erosion for the whole Mississippi Valley has been placed by geologists at not more than one foot in 4,000 to 6,000 years.

Nature's method of developing and of maintaining the productive capacity of fields has always been that of returning to the soil the whole crop, but, even so, nowhere has the concentration of the mineral elements of plant food been large as a result of soil formation by rock weathering under plant growth. The reverse rather has been the rule and very emphatically so with lime and magnesia. Only organic matter, with its ash, has at times and places accumulated to form peat and coal but always under non-agricultural conditions. There appears, therefore, no ground for a difference of opinion as to the point that it is possible for a mere rotation of crops, coupled with good tillage, and ample and timely moisture supply, to indefinitely maintain high yields where the whole crop above ground is regularly and continually removed from the field.

Concentration of Soil Solutions.

Notwithstanding the contention made in Bulletin 22 of the Bureau of Soils, and reiterated in later publications from the same office, that all soil solutions have essentially the same concentration, it must nevertheless be admitted that no observations yet published can be regarded as indicating even the approximate concentration of a single soil solution as it exists in the soil and functions in the growth of plants under field, greenhouse or pot culture conditions. It must further be admitted that the water solutions which have been recovered from soils do show a very wide range, in both composition and concentration, when judged by any standard admissible from the cultural point of view.

It is of the greatest importance in the con-

sideration of this question to recognize the fact that neither the water solutions decanted from soil samples, the water filtered through soil, nor the solutions separated from field soil by either natural drainage or a centrifuge represent either the relative composition or the concentration of the portion remaining behind in contact with the soil. The only conclusion which is warranted, based upon existing published data regarding the concentration of soil solutions as they exist under field, plant house and pot culture conditions, is that they are certainly an undetermined amount stronger than would be indicated by the observed concentrations of solutions recovered thus far from soils under such cultural conditions.

It had been demonstrated in the laboratory of the Bureau of Soils, before the data presented in Bulletin 22 had been obtained, that when a coarse, thoroughly acid-cleaned and washed sand known to contain 84.71 parts per million of NO_3 in so soluble a form as potassium nitrate was washed three minutes in twice its weight of water, only 73.7 per cent. of the actual amount present was recovered in the first washing, and after ten consecutive similar washings there was still retained in the moisture films closely investing the sand grains 18.02 per cent. of the original amount given to the sand, which amount was subsequently recovered after rendering the sand water-free. After the sixth washing, in this experiment, the strength of successive solutions became constant at .11 part per million of NO_3, the concentration standing as below:

1	washing	31.210	p. m.
2	washings	3.284	"
3	"	.452	"
4	"	.174	"
5	"	.138	"
6	"	.128	"
7	"	.111	"
8	"	.110	"
9	"	.110	"
10	"	.110	"

Schreiner and Failyer, in Bulletin 32, Bureau of Soils, have since published similar results, working with very soluble phosphates and potassium chloride in connection with several soils. The simplest explanation for results like these is to suppose that these salts are retained in solution within the stationary films investing the sand and soil grains and that the salts recovered by successive washings after the concentrations become constant, measure the rate of outward diffusion from the stationary film into the free water. But the Bureau of Soils holds (and presumably the authors of Bulletin 32) that the fact that, after prolonged leaching of soils with pure water, the filtrate appears to attain a constant concentration, furnishes direct proof in support of the contention that all soil solutions have a concentration sensibly the same, the thought being that certain amounts of the salts experimented with had been absorbed by the soils, which were later redissolved by the excess of water on its passage over the soil grain surfaces. It is to be observed, however, that in the case of the solutions and soils reported upon by Schreiner, the salts retained, even in the case of phosphates, had not become sufficient to make the retained water a saturated solution under conditions not affected by the soil surface action. It must, therefore, be admitted, we think, that the data of Bulletin 32 lends little support, such as is being eagerly sought, in defense of the views of Bulletin 22, to wit, that in all cultivable soils the moisture is a nutritive solution having sensibly the same concentration.

So far is this view from being a demonstrated fact that if the data presented in Bulletin 22 in support of it be admitted in evidence quite the reverse proposition must be counted proved by nearly every table there presented. To illustrate: The data on pages 31, 32 and 33 show a range of soluble phosphoric acid varying from 12 parts per million of soil moisture to 203 parts per million, supposing the water content in each soil sample to be 20 per cent., computed on the dry soil. That this wide range in concentration is not due to exceptional cases is made clear by arranging the data of this table in an ascending series; averaging in groups of ten to reduce errors and unusual irregularities, we get the following series of concentrations: 16.8, 28.8, 37.2, 41.7, 45.4, 50.3, 54.6, 59.8, 64.3, 70.6,

86.7 and 165.8, the last average containing but four analyses.

This table here referred to contains only analyses of a single soil type known as Cecil clay as it occurs in the vicinity of Statesville, N. C., and instead of indicating that all soil solutions have the same concentration, if it proves anything, it shows that even one and the same soil type, as mapped by the Bureau of Soils, may carry solutions of phosphoric acid ranging all the way from 16 to 165 parts per million, if indeed not from 12 to 203 parts.

But from what has been demonstrated regarding potassium nitrate from clean sand, and indeed from the data presented in Bulletin 32, referred to above, there is every reason to think that the first three-minute washing to which these soil samples were subjected should not be expected to give a solution which would indicate the true concentration of the fixed water films investing the soil granules and soil grains, and which must be regarded functional in root feeding, and hence the true difference between the extremes in this series of soil samples should be expected to be much greater than that observed.

During the year of preliminary studies regarding the nature and concentration of soil solutions preceding the collection of the data presented in Bulletin 22 a very carefully selected series of samples of soils was taken by the writer from 67 localities covering 41 of the bureau's soil types, distributed in seven states, each sample being always a composite of four cores taken with the soil tube instead of with the auger. The total water soluble salt content in the surface foot of 66 samples from these soil types were determined by the gravimetric method, the residues being dried at 110° C. before weighing. These results showed an extreme variation ranging from 105 parts per million of soil solution, computed to a moisture content of 20 per cent. of the dry soil, to as high as 1,962 parts; and when this series of determinations is arranged in an ascending order and the analyses averaged in groups of ten the concentrations stand 239.5, 418.1, 546.8, 673.7, 810, 950 and 1,530 parts per million, and when these differences are shown with only three-minute washings in water equal to five times the weight of the soil, in its fresh, normal field condition, a liter of the solution being evaporated in each case, it is difficult to understand how such data, originating in the bureau, should have been ignored in drawing conclusions so at variance with the experimental records. In the case of the phosphoric acid for this series, which was determined for each of the surface four feet separately and the data published in Bulletin 26 of the bureau, the extreme range of phosphates is from 1.64 to 39.56 parts per million, and when grouped and averaged in tens as in previous cases, the results are 3.64, 6.65, 9.65, 12.43, 17.57, 26.73 and 35.56 parts per about 4,000,000 of dry soil. In Bulletin 26 there are also given data from various sources regarding drainage waters from England, analyzed by Way, Frankland and Voelcker, all of which show strong differences in the concentration of soil moisture as it leaves natural field soil by way of underdrains. It must be conceded, therefore, that there is no good foundation in observation or, indeed, from *a priori* considerations, for the contention that all soil solutions have essentially the same composition and concentration when viewed from the standpoint of their function in plant growth.

Soluble Salt Content of Soils in Relation to Yield of Crops.

It is further contended, from data presented in Bulletin 22, that there is no apparent relation between the yield of crops and the soluble salt content of soils and the statement is quite true when thus based. But it should be generally understood that were the converse of this contention very strongly marked such data as are collected and presented in Bulletin 22 must be expected to fail utterly to reveal the fact. These are the facts regarding the data used: (1) Assumed, not measured, yields of crops form the basis of comparison; (2) single and isolated soil samples for determination are taken to reveal field conditions, which they seldom do closely; (3) much of the chemical work was done outside the laboratory under conditions prohibitive of the necessary accuracy; (4) duplicate solutions prepared from

the same sample of soil are recorded as differing by as much as 6.38 and 12.34 parts per million for PO_4; 3.15 and 23.39 for NO_3; 9.43 and 15.33 for K. It would be strange indeed if, under such conditions, anything but a medley of results were secured.

But the results of a whole season of much more critical and reliable work along these lines which preceded the gathering of the data in Bulletin 22 and a second year's work following this, still more critical and exhaustive, are left out of consideration wholly in reaching the conclusion under discussion. The first year's work referred to pointed strongly to the conclusion that, where other conditions of growth are equally favorable, the largest yields of crops are not only associated with the soils yielding the largest amount of water-soluble salts, but that the sap of crops growing on such soils is also richer in the same salts. In other words, it had been shown that on soils from which the largest amounts of water-soluble salts could be recovered more of the same salts were carried in the sap of the plants growing upon these soils, and the data may be found in Bulletin No. 26 of the Bureau of Soils, in which the letter of transmittal acknowledges the accuracy of the data but rejects the conclusions drawn therefrom.

The second year's work, whose results are throughout in accord with those of the first year, show the following relation between yields and the water-soluble salts which had been recovered from eight soil types upon which two crops were grown to maturity under normal field conditions and where the yields were accurately determined by weighing. The soil types used were selected with a view to having those of different productive capacity, and four of those were rather above, and the other four rather below, the average of good soils. Taking the yields and the water-soluble salts recovered from the poorer soils as 100, the relations found are as stated below:

	Four Poor Soils	Four Good Soils
N+P+K in samples once washed..	100	188.5
N+P+K in " 11 times " ..	100	193.1
Yield of shelled corn.....	100	191.7
Yield of potatoes.....	100	271.4

It is here clear that there is a marked increase in yield, both of corn and of potatoes, where the water-soluble salts carrying nitrogen, phosphorus and potassium are present in largest removable amounts, whether this is shown by one or by eleven washings of the same sample.

Not only was this strongly marked relation shown to exist when the soils are thus grouped, but four equal areas of each of the eight soil types were treated to 300 pounds of guano and other fours to 5, 10 and 15 tons of stable manure respectively, and the differences in recoverable water soluble salts determined throughout the season, together with the yields of corn and potatoes, with the results given below. In this table each value is a mean from 32 field plots.

	Soluble N + P + K	Yield of Corn	Yield of Potatoes
No fertilization ...	100	100	100
300 pounds guano..	103.1	110.5	117.2
5 tons manure....	106.8	120.9	131.7
10 " "	109.7	135.9	141.9
15 " "	113.5	140.0	157.4

It is thus here shown that with each increase in the amount of the three plant food elements which could be recovered from the soil there was a regular and corresponding increase in the yield of each of the two crops, the gain in the corn being almost directly proportional to the increase of the three plant food elements recovered by water from the soil. With data thus strongly indicating larger yields associated with increasing amounts of water-soluble salts recovered from the soil, collected before the data of Bulletin 22 and confirmed by a second year of still more critical work, the whole work is ignored and the reverse relation held to be demonstrated by data of the character stated.

Soluble Salt Content in Soils Constantly Maintained.

This is another of the contentions woven into the fabric of Bulletin 22 but without basis in recorded data other than that spread upon its pages in the form of analyses of some Rothamsted soils which are offered to introduce the statement "that the decreasing

yield from the continuously unmanured wheat plot has not been due to a loss of water soluble material, or rather that there has been no permanent disturbance of the solution equilibrium and concentration," citing especially the bureau's analyses of soils from plots 3 and 11 of the Broadbalk field. Such data are given in evidence, utterly ignoring the detailed, full and careful data published from the Rothamsted laboratories pointing strongly to the very opposite conclusion, as may be seen from the tables, Bulletin 26, Bureau of Soils, pp. 23, 24, 80, 83. The detailed analyses of the soil solutions leaving the Rothamsted plots as drainage water show that that from the plot continuously unfertilized are not only the least concentrated of any in the whole series of 16 plots, but that the total solids in solution from this plot stand as 246.4 to 425.9 coming from plot 11, or as 100 to 173, while the relative mean yields of wheat stand as 100 to 215. Moreover, there is a remarkable and clear relation between the yields of nearly all of the plots of this series and the concentration of the drainage water leaving the respective plots, the yields generally increasing with the soluble salt content of the drainage water. Not only is this true for the total soluble salt content, but the amount of potash carried in the drainage water coming from the plots to which potash fertilizers have been continuously applied, when compared with that from those to which none has been given, stands in the ratio of 425 to 100, as an average, and there is no individual exception.

Such, in brief, is the character of the data spread out by Whitney and Cameron in Bulletin 22. Thus did they ignore pertinent, undoubted facts collected by the bureau or published elsewhere, tending to disprove their views. Such is the almost utter lack of evidence collected either by the bureau or by others which may fairly be placed in support of their main contentions, and yet no work has since been done, or at least published, which can be placed in support of these views. On the contrary, the energy of the bureau is being expended in an effort to accumulate data in support of the theory that poor and runout lands are so because of the accumulation in them of imaginary toxic substances. Bulletins 36 to 40 record their most strenuous efforts along this line.

Toxicity as a Factor in the Productive Capacity of Soils.

In Bulletins 36 and 40 are given general reviews of literature relating to this subject, and in these and No. 28 the main body of experimental data thought to support the theory that soils are rendered unproductive by poisonous excreta thrown off by the roots of higher plants. However plausible and attractive such a theory may appear, a review of the data and discussions presented will convince the unbiased student that little has yet been done which may properly be considered other than speculative contributions to the subject. As pointed out, the main contentions of the Bureau of Soils supposed to make the consideration of the toxicity factor pertinent are not supported by its own work or that of others and are not true. It has made no discovery, therefore, demanding such a factor; but while this fact should be clearly recognized, it may be well to retain the old theory in the list of alternative working hypotheses, although it must be conceded to offer less of promise than many others or than it did when originally proposed, for our present knowledge makes it quite uncalled for in explaining observed relations.

But were it true that toxic excreta do play an important rôle in rendering soils unproductive, it must be admitted that nothing yet has been published, either by the Bureau of Soils or others, to which reference is made by the bureau, which should in any sense be regarded as proof. Indeed, much of the bureau's data can hardly rank as even suggestive evidence regarding the existence of such conditions in the field; because nearly all of the work has been done with seedlings placed under extremely cramped, abnormal and unsanitary conditions, the plants fed chiefly by the small amount of nutrients stored in the seed, and the experiments terminated after a few days or at most after two or three weeks. In illustration, take the ex-

periments with agar agar, where wheat seedlings are grown inside of glass tubes with inside diameters less than that of an ordinary lead pencil (6 to 8 mm.) and 3.3 cm. long; three such tubes placed end to end, supported on a glass rod with their ends separated 2 to 3 mm., thus forming a segmented tube to be filled with transparent agar agar, solid when cold, and standing in similar agar contained in a glass vessel, the whole system arranged to be revolved on a klinostat to neutralize the directive effect of gravity. When previously germinated wheat plants are transplanted into the agar inside one of these tubes before it has solidified, and compelled to grow with its roots thus circumscribed it is held that if toxic excreta are developed they will become so potent as to compel the roots, when they reach a gap between two segments, to turn from their course along the axis of the tube and grow outward into the fresh uncontaminated agar of the outer vessel. It is assumed that if more roots turn outward, the presence of a toxic substance is demonstrated, and further, that the toxic substance was excreted by the roots and is a normal and necessary function under field conditions.

Plants were grown in free agar in large numbers until the roots, by assumption, had charged it with toxic substances; such agar was then remelted and filtered and used to fill other tubes or to surround tubes containing fresh agar, the contention being that if the outside agar is more toxic than that inside the tube a smaller number of roots would grow outward into the poisoned agar. Just why any should grow outward into the poisoned agar is not made clear; probably it is because those particular roots had rendered the immediate contact agar more toxic than that outside! But seriously, the experiments would seem to be quite as conclusive a proof that the roots growing inside the tube, or growing in the free agar, have reduced the water content of the agar or its soluble salt content and that the roots simply turned one or the other way according as available water or soluble salts are more abundant. Our own observations have shown that plant slips placed in water containing sugar, dextrine, agar agar in the condition described by the Bureau of Soils, and even in water holding suspended clay, wilt sooner or become less turgid than check slips placed in pure water, thus indicating that water is less readily obtained under those conditions. It is certainly to be expected that when as many wheat roots grow under such cramped conditions as are here under consideration, as are reported in the bureau's experiments, there must be developed a stress for water and it seems just as rational and quite as certain that the deflection of the roots may have been due to this condition. The growing of large numbers of plants in free agar agar would certainly reduce the per cent. of water and the melting of it over would reduce it still further. As it is not said that strict quantitative measures were taken to secure absolute equality of water and salt content between the inside and outside agar, the results are subject to the same interpretation as that suggested. These ingenious experiments, therefore, can not be seriously held to demonstrate that roots excrete toxic substances, neither can it be held that even if toxic substances were developed as either normal or abnormal conditions the deflection of the roots was due to them, and there is nothing in the whole range of experimental work covered by the three bulletins in question which can be held to establish, or even necessarily suggest, a probability of toxic substances in soils which seriously affect their productivity.

The loose reasoning here referred to, and characterizing the whole of Bulletin 40 and indeed of the other two as well, appear, to the writer, so out of accord with the planning and execution of these particular experiments with agar agar, when coupled with our personal acquaintance with the one whose name appears as senior author, that we are unable to feel that either the language used or the conclusions drawn are his. This I do know: It was my great surprise and misfortune, after having submitted manuscript for publication, to find my own name on the printer's proof as joint author of Bulletin 22, maintaining views directly opposed to those we had submitted and which had been laid aside, not to be pub-

lished "until after the bureau had expressed its views." This much in justice appears necessary to avoid placing criticism where it may not belong. It can never be the privilege of the head of a government bureau to subscribe the names of subordinates to views he knows they do not hold. Indeed, the interests of science, if not a sense of justice, should impel any chief to encourage in his subordinates the greatest freedom of expression of views on scientific problems of investigation and to avoid in every way indicating the supposed trend of lines of experimentation from which data are sought.

The true character of some of the more recent evidence being presented in defense of Bulletin 22, along the line of toxicity studies, can be better understood from the closing sentence in Cameron's preface to Bulletin 28, when the facts in the case are known. Cameron says:

> The authors of the present paper have had a leading part in the development of the work which the bureau has been conducting along these newer lines of soil investigation, and it is believed that the description of the investigations which have made possible the production of a luxuriant lawn upon a naturally unproductive soil at Takoma Park, Maryland, as well as helped in a very large measure in the development of our present views concerning soil fertility, will mark a decided step forward in soil studies and prove suggestive to other investigators in this most important branch of applied science.

The facts regarding the investigations *"which have made possible the production of a luxuriant lawn upon a naturally unproductive soil"* in Professor Whitney's front yard in Takoma Park, as pointed out by Cameron, are these: In August, 1904, the area to be treated was dressed with stable manure at the rate of about forty tons per acre and the soil, which at the time was filled with a dense network of tree roots, many of them large, making it difficult to dig, was spaded and then seeded to lawn grass which came up and, during the fall, looked well. Cameron thought he saw the utter rout of the bureau's toxicity demon from this lawn and the transformation of a *"naturally unproductive soil"* into one of rare fertility. But the severe root pruning and the loosening of the soil incident to spading in the manure, combined with the fall rains and cool weather which gave the grass seed exceptional facilities for growth, at the same time provided excellent opportunity for the development of new and active tree roots, as was later discovered by the bureau; and early in the spring of 1905, as reported in Bulletin 40, the ground became "almost completely filled with young active growing tree roots." The plain and simple fact is, these roots so thoroughly sapped the soil of its available moisture, rendering it so hard and dry, that early in May the grass had died. Nevertheless the preface was allowed to stand.

The new roots in the lawn soil were discovered and the thought at once arose *"that these might exercise some malignant effect upon the growth of grass."* Five full tablespoons of soil each were effectually paraffined into the standard wire baskets; in these were carefully transplanted young trees of pine, maple, tulip, dogwood and cherry, two baskets being reserved without trees as checks. This done, equal numbers of germinated wheat seedlings were set out about the trees in the baskets and allowed to grow two to three weeks, replanting as the stress became too severe, until at the end of the season 81 trials had been made under such rigid laboratory control—and with the remarkable result that in all but 10 of the 81 trials the green weight of the wheat trials was less where the wheat grew under the trees! Moreover, the bureau wisely observes, this reduced yield occurred in spite of the fact that the roots of the several wheat crops were left in the soil, which must have acted as green manure and thus tended to counteract the deleterious effect of the tree roots on the wheat (p. 19, Bull. 40). Then again, and with characteristic logic, the better growth of wheat under the trees in the last three crops is ascribed to the trees passing into the condition of winter rest.

It is thus the pages run on and one bulletin follows another, all having the same indecisive and misleading character; all clearly bearing the stamp of two minds, although dif-

ferent authors may be assigned on title pages. If the bureau really has faith in its utterances, why will it not rise to the stature of serious work and get out upon some field with appliances which will enable it to extract from one or more of its highly unproductive soils the toxic substances about which it has written so much and yet in reality accomplished almost nothing? This the farmers of the country have a right to demand, or else that it shall turn at once its energies into channels which have more of promise.

Since writing the above there has been issued from the bureau (November 6) another bulletin, No. 47, along the same line, under the title "Certain Organic Constituents of Soils in Relation to Soil Fertility" which, not to be misleading, and to be true to the subject-matter presented as well as to the facts as known with which the bulletin deals, should read *Certain Organic Constituents in Plants in a Possible Relation to Soil Fertility;* for although it is stated (p. 9) that "The toxic properties of soils have been demonstrated and the existence of toxic bodies is a reality with which it is necessary to deal in future soil studies on the fertility and infertility of our agricultural lands," and further along it says (p. 12): "It has been demonstrated by the studies described in this bulletin that substances commonly used as fertilizers in agricultural practise have in addition to their function as plant nutrients a well-defined power to overcome and actually destroy toxic bodies," yet the facts are nothing which the bureau has yet published can be considered strictly as *demonstrating* either of these propositions even under the strained and highly abnormal conditions of the experiment cited, not to say what does occur under normal field conditions.

In these experiments, as heretofore, ten wheat seedlings are grown but six to thirteen days in solutions contained in 250-c.c. salt bottles, depending for nourishment upon materials stored in the seed, while the chief criteria for differences in growth have been the very misleading and indecisive quantities of transpiration or of green weights, whereas, in such experiments as these, it is perfectly feasible to determine precisely the increase in dry weight, both in tops and roots, and thus obtain quantities which can not be misleading, as those used are known to be, and so acknowledged at page 15 of the bulletin. Moreover, in each of the experiments cited with tyrosine, choline, piperidine, quinone, vanillin, cumarin, cinnamic acid, esculin and heliotropine it is quite as rational to assume as another, among several alternative hypotheses, that the real effect of these substances, instead of being in any sense toxic to the wheat plants, has been to simply diminish the rate at which the stored nourishment in the seed was rendered soluble and available to the growing seedlings. Indeed, the coating of the roots in several of the cases, as cited in the bulletin, suggests that the substance of the kernels may have been markedly affected in such a way as to have retarded its transformation into available plant food, and the failure of the roots to develop into the solution may quite as well have been due to a lack of dissemination of plant food, so that there was little to stimulate root development in those cases, for it is a fact well established by observation in the field that the roots of crops develop most strongly into portions of the soil where nutriments are most abundant and available. It would clearly be a waste of energy and of food materials for a plant to develop its roots into a non-nutritive solution and these experiments were never continued long enough to have developed a stress for water. It is worthy of note in this connection that often there was associated with the substances used a relatively less root development than of top if we may judge by the appearances of the illustrations, supplemented by definite statements to this effect in the text. It is greatly to be regretted that where so much pains has been taken to accumulate data and where the dry weights of the roots and of the tops could with ease and exactness have been determined, it was not done, as the extra time, expense and labor are not worth considering in view of the increased value of the data which would have resulted. We speak advisedly on this point because we have done a large amount of work along the

lines of transpiration and green weights in plants in relation to the dry matter produced, the observations covering the full life of the crop, coming to complete and normal fruitage.

In the case where wheat seedlings were grown a second time in the same supposedly toxic solutions a better growth would be expected if these substances had the effect of simply rendering the nutrients of the kernels less readily transformed into available food, and it is quite possible that crushed wheat kernels placed in these solutions, thus eliminating the vital activities of seedlings, might have affected them as favorably as did the growth of the first crop and might have caused a disappearance or a reduction in the amount of the toxic substance. These experiments, therefore, can not be considered fully demonstrative. For the same reason, and because transpiration is not a measure of growth, the experiments with nitrates and with lime are also inconclusive.

But granting that the data of Bulletin 47 do demonstrate that the substances experimented with are truly toxic to wheat seedlings under the highly cramped and abnormal conditions of the experiment, it will be conceded quite rash to affirm that these substances in like quantities would be found similarly toxic in the soil under field conditions until it were known, not only that such substances do exist in the field soils, but also that they are more abundant in those which are unproductive.

The unwarranted publication of such positive conclusions as those quoted becomes still more evident when an effort is made to give quantitative expression to the recorded data of Bulletin 47 in terms of field conditions correlated with other contentions of the Bureau of Soils. It is maintained by the bureau, but without sufficient evidence, that the capillary movement of soil moisture under crop conditions is of negligible magnitude and that for this reason the roots of crops, in order to secure moisture and plant food and also in order to place the active absorbing root tips into fresh soil not poisoned by their own excreta, are compelled to constantly advance into previously unoccupied soil, and they are known to spread throughout a depth exceeding three to four feet in the case of most crops. The toxic substances of unproductive soils must, therefore, be deeply distributed throughout the root zone and to a depth of at least four feet. But the strongest solution used in the experiments of Bulletin 47, of 1,000 parts per million, means not less than 2,800 pounds per acre of field where the water content of the soil is 20 per cent. and it would mean 700 pounds per acre for the surface foot alone. In the case of 100 parts per million the amounts would be 70 pounds and 280 pounds per acre for depths of one and four feet, respectively. In the light of failures up to the present time to isolate these toxic substances from soils it will hardly be seriously contended that any such large amounts of toxic substances do exist in unproductive soils. But the smaller amounts experimented with, as recorded in Bulletin 47, either had little or no effect or they produced positive increases in growth. If, therefore, the data of the bureau along this line of toxic substances are to be given serious consideration at all, Bulletin 47 must be regarded as suggesting that on account of the probably small amounts of these toxic substances present in soils, and on account of their observed small, or else stimulative, effect when present in such quantities, toxic substances are either negligible factors in soil fertility or else they are beneficial to crops.

F. H. KING
MADISON, WIS.

SPECIAL ARTICLES

A NEW APPARATUS FOR MEASURING ELECTROLYTIC RESISTANCE[1]

THE measurement of electrolytic resistance differs from that of a metallic conductor in several respects. The most evident difference is that the electrolyte has no definite shape or size. Cells of various forms have been devised to hold the solution while it is being measured and I would hardly venture to add another to the list were it not for the fact that the

[1] Paper read before Section B of the American Association for the Advancement of Science and the American Physical Society in joint session, Chicago, December 31, 1907.

form shown in Fig. 1 has proved so very useful in the laboratory and also that several teachers who have seen the apparatus have desired a duplicate for their work. And there may be others who would find such a cell as useful as this one has been.

The principal object in the design of this cell is to present the concept of "molecular conductivity" of an electrolyte in such a clear and concise form that no one who is capable of making electrical measurements can misunderstand it. The apparatus consists of a strong glass tube provided with a small side tube for filling. Both ends are ground plane and closed by platinum-faced electrodes, the whole being firmly clamped together in a suitable framework. Good insulation between the electrodes is provided by making a portion of this framework of ebonite, as shown in the figure. Crushing strains due to the unequal contraction of glass and metal are avoided by

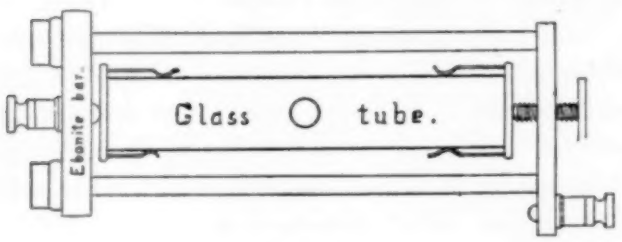


FIG. 1

the use of heavy rubber washers, one on each side, which take up the extra length without much increase in pressure. It has been found that a moderate pressure is sufficient to prevent leakage between the ends of the glass tube and the mental electrodes. The apparatus is supported by four short legs not shown in the figure.

The resistance of the column of liquid contained in this tube is measured by the method of Wheatstone's bridge, using a telephone and alternating current. The specific resistance, s, of such a conductor has the same meaning as for a metallic wire and is given by the same relationship,

$$s = r\,A/L,$$

where A is the cross-section and L the length of the column whose resistance is r ohms. Both A and L can be measured directly, and each has a very definite and unmistakable meaning which is readily understood by the student. This can not be said regarding the equivalent "constant" of a cell which has no definite dimensions.

The specific conductivity, c, or the conductivity of a centimeter cube of the solution from one face to the opposite one, follows at once as the reciprocal of this. Or

$$c = 1/s = L/rA.$$

Since the conductivity of an electrolyte depends upon the amount of the substance in solution—that is, upon the number of ions per cubic centimeter—if the conductivities of different solutions are to be compared it is necessary to express the concentrations in comparable terms. This is usually done by stating the number of gram molecules, m, of substance that are dissolved in each cubic centimeter of the solution. The molecular conductivity, μ, of an electrolyte is then defined as the conductivity of a centimeter cube of the solution per gram molecule of salt within this cube. In symbols,

$$\mu = c/m.$$

Presented thus there is rarely a student who does not understand from the first the meaning and significance of the molecular conductivity of an electrolyte. No claim is made that this apparatus is specially adapted for refined research or that it is the best form for the expert. For example, it can not well be placed in a constant temperature bath as is necessary for all refined measurements. But nevertheless when working at room temperatures, and using solutions which have stood in the same room for some time, very satisfactory results can be obtained, and for the purpose for which it was designed this apparatus has met every requirement.

ARTHUR WHITMORE SMITH
UNIVERSITY OF MICHIGAN

THE AMERICAN ASSOCIATION OF MUSEUMS

THE American Association of Museums will hold its third annual meeting in Chicago, May 5–7, as the guest of the Chicago Art

Institute, the Field Museum of Natural History and the Chicago Academy of Sciences.

In addition to the usual program of papers, three special features are proposed for the meeting:

1. *An exhibit of museum devices.* This is intended to include devices of all kinds which, whether original or not, have proved useful in various museums.

2. *A discussion of the future work of the association.* An effort will be made to determine the advisability of undertaking certain lines of work which have been proposed. Among these the most prominent are:

(*a*) Publication of a Directory of American Museums of Art and Science. The secretary will submit data concerning the cost and scope of this work and general discussion of these data is desired.

(*b*) Publication of an annual table of museum statistics, either as a supplement to the directory of museums or independently.

(*c*) Establishment of a bureau of information and permanent exhibit of museum technique, to which museums would contribute plans of buildings and cases, samples of labels and other devices of installation, etc., and to which museums may apply for information on matters of museum practise and perhaps for loan of samples.

(*d*) Advisability of publishing a journal.

3. *A general discussion of topics of special interest.*

(*a*) Educational work of museums. In view of the wide interest manifested in various phases of the educational work of museums, the time seems ripe for a general discussion of the relation of educational work to other museum functions and for a concise review of the educational work actually being done, with a discussion of practicable means of cooperation between museums. It is desired that this discussion shall serve to define the attitudes taken by the various classes of museums of art and science to this subject.

(*b*) Reciprocal relations between museums in securing the services of lecturers and experts, in carrying on field explorations, and in exchange of economic and educational collections.

(*c*) Adaptation of buildings to museums, including a discussion of floor plans, natural and artificial lighting, and the general arrangement of exhibits and grouping of subjects. Exhibits of floor plans will facilitate discussion of this subject.

(*d*) Methods of exhibiting valuable books.

(*e*) Advisability of free distribution of museum publications.

Members who attend the meeting are requested to come prepared to discuss these subjects and to contribute to the exhibit of museum devices whatever is likely to be of interest to others. Inquiries and suggestions may be addressed to the secretary.

Announcement of headquarters and other details will be made shortly by the entertainment committee.

PAUL M. REA,
Secretary

THE CHARLESTON MUSEUM,
CHARLESTON, S. C.

SCIENTIFIC NOTES AND NEWS

As a matter of information for those who plan to attend the summer meeting at Dartmouth College, beginning on June 29, the local committee thinks it proper to mention the facilities for reaching that place. The railroad station is known as "Norwich and Hanover" on the Passumpsic Division of the Boston and Maine Railroad. White River Junction, four miles south of Hanover, is the center of four lines of railroad: The Concord Division of the B. & M. system; the Central Vermont Railroad and the Connecticut River Division, B. & M. R. R. (eight hours to New York) and also connecting at Greenfield and Springfield (Boston and Albany R. R.) for the West; the Central Vermont Railroad, making connection with Montpelier, Burlington and the West (thirty hours to Chicago); the Passumpsic Division, B. & M. R. R. (eight hours to Montreal). It may be added for the benefit of members who would come by way of New York that the White Mountain express will probably be put on for the summer about that time. This train has heretofore left New York at 8:40 A.M., and is due at Hanover Station at 4:45 P.M.—a through train from

New York without change of cars. The regular fare is about $5.85, the distance 265 miles.

The summer meeting of the American Chemical Society will be held in New Haven on Tuesday, Wednesday and Thursday, June 30, July 1 and 2.

The celebration of the hundredth anniversary of the birth of Charles Darwin and the fiftieth anniversary of the publication of "The Origin of Species," planned by Cambridge University, will be held on June 22, 23 and 24, 1909. Arrangements are being made by the New York Academy of Sciences and by Columbia University to celebrate the hundredth anniversary of Darwin's birth on February 12, 1909. This is the birthday of Lincoln as well as of Darwin and, being a public holiday in New York State, will give a suitable opportunity for the celebration.

Nature states that Lord Rayleigh will probably be elected to the vacant chancellorship of the University of Cambridge in succession to the late Duke of Devonshire. Lord Rayleigh was professor of experimental physics at Cambridge from 1879 to 1884.

On the nomination of the Prussian Ministry of Education Dr. Max Verworn, professor of physiology at Göttingen, has been appointed to be Kaiser Wilhelm professor at Columbia University for the year 1908–9.

Dr. Robert Koch arrived at New York from Bremen on the *Kronprinzessen Cecilie* on April 7. The German Medical Society gave a banquet in his honor on April 11.

Professor A. Crum Brown, F.R.S., professor of chemistry in the University of Edinburgh, proposes to retire from the chair which he has occupied since 1869.

The British Society of Dyers and Colorists met on April 3, at Bradford, when the president, Professor R. Meldola, F.R.S., delivered his presidential address on "The Founding of the Coal-tar Color Industry." The first awards of the Perkin medal were made to Professors C. Graebe and C. Liebermann for their synthesis of alizarin.

In commemoration of the twenty-first anniversary of Sir William Ramsay's election to the chair of chemistry in University College, London, the professors of the college entertained him at dinner on March 18. The provost, Dr. T. Gregory Foster, was in the chair, and covers were laid for eighty guests.

April 9 marked the twenty-fifth year of service in the United States Department of Agriculture on the part of Dr. Harvey Washington Wiley. An appreciation of his work was evidenced in a dinner given him on the anniversary at Hotel Astor, New York City. About two hundred prominent members of the chemical profession attended. The officials of the committee in charge of the dinner were, Professor Charles Baskerville, chairman; Dr. Walker Bowman, secretary, and Mr. Maximillian Toch, treasurer. Dr. William J. Schieffelin acted as toastmaster. Many prominent chemists spoke, congratulating Dr. Wiley on completing a quarter of a century's work for the government in behalf of its people. An embossed album with the signatures of those attending the dinner was presented to him.

According to foreign journals the Paris Academy of Sciences has appointed a committee, composed of MM. Becquerel, Bouquet de la Grye and Poincaré, to consider a suggestion by M. Bouquet de la Grye concerning the application of wireless telegraphy to the problem of the determination of longitude at sea. The idea is to utilize the wireless telegraph station of the Eiffel Tower in order to send, for instance, every night at midnight a Hertzian signal giving the time of the meridian of Paris. M. Bouquet de la Grye thinks that if a station were established at the Peak of Teneriffe signals could be detected completely around the earth.

The ninth lecture in the Harvey Society course will be given at the New York Academy of Medicine building on Saturday evening, April 18, at 8:30 P.M., by Professor Alonzo E. Taylor, University of California. Subject: "The Rôle of Reversed Ferment Reactions in Metabolism."

A bill has been passed by the Virginia legislature establishing a Virginia State Geological Survey. The bureau is to have its headquarters at the University of Virginia,

and the board is to be composed of the governor (*ex officio*), the president of the university, the president of the Virginia Polytechnic Institute, and two citizens. An annual appropriation of ten thousand dollars is provided.

BY the conjoint action of the National Academy of Sciences and of the trustees of the Elizabeth Thompson Science Fund a table has been secured permanently for the use of American investigators desiring to work at the International Scientific Station on Monte Rosa. This station offers facilities for work in physics, meteorology and physiology, but any appropriate research may be carried on there. The right of appointment to the American table vests in the trustees of the Thompson Fund. Applications for appointment should be addressed to the secretary, Dr. Charles S. Minot, Harvard Medical School, Boston, Massachusetts.

A MOVEMENT is under way to secure the use of the new congressional office building or a part of the capitol to house the International Congress on Tuberculosis that is to be held in Washington next September. A great exhibition illustrative of what is being done, the world around, in the fight against the disease, will be held in connection with the congress, and the two will continue from September 21 to October 12.

THE International Congress of Navigation, which is to be held in St. Petersburg in June, is organized by the International Association of Congresses of Navigation, which has its permanent commission in Brussels, composed of delegates from the various states that have joined the association. The chief aim of the congress will be the consideration of questions connected with river and canal navigation and the industrial and commercial use of waterways and seaports.

THE Paris Academy of Sciences has received a legacy of £400 from M. Sabatier to found a biennial prize to be known as the Sabatier prize.

ADVICES from Sydney state that the zoological gardens there are at present particularly interesting to visitors by reason of the inclusion of over 100 rare birds and animals destined for the London Zoological Society's show at the Franco-British Exhibition this summer. These specimens will be shipped for England by a steamship scheduled to sail from Sydney on April 11 and due in London on June 7.

UNIVERSITY AND EDUCATIONAL NEWS

PRINCETON UNIVERSITY has received $250,000 from Mrs. Russell Sage for a freshman dormitory. The university has also received $130,000 from other sources, including over $50,000 from the General Education Board.

COLUMBIA UNIVERSITY has received $100,000 from the children of the late Rev. Orlando Harriman, who graduated from Columbia in 1835, to be used for the endowment of a chair in English. Other gifts to the university, amounting to $40,000 are also announced.

THE medical schools of Indiana University and of Purdue University will be united and conducted under the charge of Indiana University. A complete medical course of four years will be conducted at Indianapolis, while the first two years will also be given at Bloomington. It will be remembered that Purdue University, which is primarily a school of engineering, was instrumental in consolidating various proprietory medical schools at Indianapolis, where Indiana University also conducted a medical school. There had been some conflict between the two schools, and it is fortunate that Indiana will now have a strong medical school under the auspices of its state university.

MR. GEORGE S. DAVIS, associate superintendent of schools in New York City, has been chosen president of the New York Normal College. The salary of this position is $8,250 with an annuity of $5,000.

THE Rev. Dr. S. Parkes Cadman, of Brooklyn, has declined to become president of Wesleyan University.

DR. M. E. WADSWORTH, dean of the School of Mines and professor of mining and geology in the Pennsylvania State College, was elected

last year as dean of the School of Mines and professor of mining geology in the Western University of Pennsylvania. The call was accepted with the understanding that he was to hold both positions and to discharge the necessary duties of both until September 15, 1908, when he would take up his permanent residence in Pittsburgh. The Western University having purchased a new site near the Carnegie Institute and the Technical Schools, Dr. Wadsworth has completely reorganized the School of Mines and prepared plans for the new $175,000 mining building, which is to be erected next summer. During the less than seven years of Dr. Wadsworth's charge of the School of Mines at the State College it has been raised from the nineteenth to the sixth in size in the United States. It has been completely reorganized and now has some of the most advanced courses of any school of mines.

Professor H. A. Winkenwerden, of the U. S. Bureau of Forestry, has been appointed professor of forestry at the Colorado School of Forestry, Colorado Springs, in place of Professor J. F. Baker, who has resigned. The curriculum of the school has been considerably enlarged, and, beginning in 1909, it is to be extended to cover four years and to lead to the degree of bachelor of forestry. The summer course will be continued as heretofore, both as a required part of the regular curriculum and as a separate course for special students, but the length of this course has been reduced to two months. During the coming summer extensive experiments on the growth of yellow pine will be begun by the school in cooperation with the U. S. Bureau of Forestry, on the Manitou Park Reserve belonging to the school.

New York University has appointed as professor of pathology and director of the laboratory of pathology of the University and Bellevue Hospital Medical College, Dr. Richard Mills Pearce, Jr., of Albany. Dr. Pearce received his degree from the Harvard Medical School in 1897. Subsequently he studied at the University of Leipsic. He was resident pathologist at the Boston City Hospital 1896–9; instructor in pathology at Harvard 1899–1900; demonstrator and later assistant professor of pathology in the University of Pennsylvania, 1900–3, and since 1903 has been director of the Bender Hygienic Laboratory at Albany; director of the bureau of pathology and bacteriology, New York State Department of Health; professor of pathology and bacteriology at the Albany Medical College.

Mr. A. O. Lovejoy has accepted a call to the professorship of philosophy in the University of Missouri, and will therefore sever his connection with Washington University, St. Louis, at the close of the current academic year.

H. B. Alexander, A.B. (Nebraska, '97), Ph.D. (Columbia, '01), now engaged in literary work at Springfield, Mass., has been elected professor of philosophy at the University of Nebraska.

The following promotions have been made at Harvard University: W. E. Castle to professor of zoology, H. J. Hughes to be assistant professor of civil engineering, John Warren to be assistant professor of anatomy. David Cheever to be demonstrator of anatomy and J. H. Woods to be assistant professor of philosophy.

President E. R. Nichols, of the Kansas State Agricultural College, has resigned, the resignation to take effect July 1, 1909. Professor C. H. Burkett, director of the experiment station, and Mrs. H. W. Calvin, professor of domestic science in the same institution, have also resigned their positions.

Mr. R. H. Biffen has been elected to the recently established chair of agricultural botany at Cambridge University. Mr. Biffen is, as recorded in *Nature*, the author of numerous papers, the earlier of which dealt with the preparation of india-rubber and the coagulation of latex, and he has devoted a great deal of attention to fungi. His researches on the hybridization of wheat and barley have attracted the attention of civilized governments throughout the world, and attempts have been made to induce him to leave England and place his services at the disposal of at least one foreign government.